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Governance, technology and craftsmanship in the Belgian window-glass industry: The Charleroi region, 1830-1914

Thesis for the degree of Doctor in History
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Abstract

This thesis contributes to the debates on the nature of the 19th-century industrialisation and technological development exploring the case of the Belgian window-glass industry. During the period between the Belgian independence in 1830 and the outbreak of the First World War in 1914, this industry experienced steady growth, making Belgium one of the most important window glass manufacturers in the world. Moreover, during this period, this industry was largely concentrated in the Charleroi region. Therefore, the study takes a primarily regional approach, adopting the Industrial-district theory as its principal conceptual framework.

The study of the history of the Belgian window-glass industry, as presented in this thesis, contributes to several historiographical topics, such as the history of the window-glass industry in 19th-century Belgium, the history of industrial districts as specific structures of business organisation, and the history of the relationships between technological innovations and craftmanship in the context of the industrial revolution. Therefore, the objectives of this study transcend the purely Belgian context, as it contributes to important international debates, taking the often-overlooked industry as a specific case.

The development of the Belgian window-glass industry is specifically explored through the examination of the governance structures that emerged in the Charleroi district, as well as through the development and management of technological innovations and their relationship to craft traditions.

The findings of this study present a picture of a dynamic industrial environment consisting of multiple actors (firms, business interest organsations, government) that showed remarkable technological creativity, integrating traditional craftmanship and technological innovations, and was characterised by business organisations that was tightly integrated in the international networks of commerce and information exchange. Yet, this organisation was not without its limitations, as exemplified by some 'dissident firms' that refused cooperation for various reasons.

Samenvatting

Deze doctoraatsverhandeling draagt bij tot het debat rond de aard van de 19de-eeuwse industrialisering en technologische ontwikkeling. De Belgische vensterglasindustrie wordt als casus genomen. Gedurende de periode tussen de Belgische onafhankelijkheid in 1830 en het begin van de Eerste Wereldoorlog in 1914, nam deze industrie een hoge vlucht, waardoor België één van de belangrijkste vensterglasproducenten ter wereld was geworden. Bovendien was deze industrie grotendeels geconcentreerd in de regio Charleroi. Hierdoor volgt deze studie voornamelijk geografische benadering, waarbij de Industriële districten-theorie als conceptueel kader gehanteerd wordt.

Het onderzoek naar de geschiedenis van de Belgische venstergalsindustrie, zoals hier voorgesteld, draagt bij tot meerdere historiografische velden, zoals de geschiedenis van de Belgische vensterglasdindustrie in de 19de eeuw, de geschiedenis van de industriële districten als specifieke vorm van ondernemingsorganisatie en de geschiedenis van de verhoudingen tussen de technologische innovatie en ambachtelijke tradities in de context van de industriële revolutie. Hierdoor overstijgt het belang van deze studie het puur Belgische niveau door aan internationale debatten bij te dragen, waarbij de glasindustrie, die vaak over het hoofd gezien wordt, als casus genomen wordt.

De ontwikkeling van de Belgische vensterglasindustrie wordt concreet in beeld gebracht via onder meer de analyse van de bestuursstructuren die in de regio Charleroi ontstaan waren en van de ontwikkeling en het beheer van technologische innovatie in verhouding tot ambachtelijke tradities.

De bevindingen van dit onderzoek tonen het beeld van een dynamische industriële omgeving, bestaande uit verscheidene actoren (bedrijven, werkgeversorganisaties, overheden) die een opmerkelijke technologische creativiteit aan de dag legden, waarbij technologische innovaties en traditionele ambachtelijke werkwijze geïntegreerd werden. Bovendien was het gekenmerkt door een bedrijfsorganisatie die nauw in de internationale commerciële en kennisuitwisselingsnetwerken geïntegreerd was. Toch kende deze organisatie ook haar limieten, zoals geïllustreerd door enkele ‘dissidente firma’s’ die om verschillende redenen samenwerking weigerden.

Acknowledgements

This thesis is a (provisional) highlight of a long and arduous journey that I initiated many years ago when I first enrolled on a distance-learning undergraduate history course. ‘Getting a doctorate in history’ had always remained my goal from the first moment. Not a minor ambition for someone whose educational background was in a completely different field and who could not attend the university as a regular student for personal reasons, having to get his Bachelor’s and Master’s degrees via the distance and evening learning trajectory while working a full-time job in a completely different field! And yet, here it is, my doctoral thesis, a testimony of hard work and dedication!

I would like to thank my supervisors, Bert de Munck and Joost Caen, in the first place. Not only did they provide invaluable guidance, advice, and the necessary challenge at every stage of my research, but they also introduced me to the world of academia, a world that had been completely alien to me previously. I am also very thankful to Inge Bertels, another member of my doctoral commission, for her help. In the same vein, I’m very grateful to my fellow PhD students, and all the other members of the Centre for Urban History, who provided a stimulating and supportive research environment. Unfortunately, a full list of those who assisted and supported me at the University of Antwerp would become too long, with the almost inevitable injustice of omitting some. Nevertheless, I would like to express my very special gratitude to Kim Overlaat. *Hartelijk dank voor alles, Kim*! Moreover, I would like to thank Liesbeth Langouche, my fellow ‘glass PhD’ at the ARCHES research group of the University of Antwerp's Design Sciences faculty. Outside the University of Antwerp, a very special thanks goes to Chris Corker from York University. Even though we have only met once in person, his unceasing interest in my research remained a great source of motivation and inspiration for me. I am also indebted to Catherine Thomas (Musée du Verre, Charleroi) and Stéphane Palaude (Université de Lille III) for their advice.

I would also like to thank the staff of many archives and libraries where I have conducted my research, such as the State Archives of Belgium in Brussels and Mons, the municipal archives of Charleroi and the Musée du Verre in Charleroi, and the documentation centre of the Museum voor Oudere Technieken in Grimbergen.

Last but not least, my deepest thanks go to Frédéric Gobbe, who kindly allowed me to make use of his invaluable private archive. It is not an exaggeration to state that without him, this thesis would not exist. *Merci cordialement, Frédéric*!

Yet, my greatest thanks go to my family, and especially to my mother, who always supported me, not only during my PhD project, but in my entire journey as well.

General introduction

This thesis is dedicated to the history of the window-glass industry in Belgium between 1830 and 1914. During this period, this industry was largely concentrated in the Charleroi region. Therefore, the study takes a primarily regional approach. At the same time, the national and even international and global context will be taken into account.

The concentration of the window-glass industry in this region originates around 1750. By the early 19th century, the region acquired a semi-monopolistic position in Belgium, as only a few window-glass factories were located elsewhere. The industry experienced spectacular growth during the 19th century, when total production grew from 1.28 million square metres in 1840 to 23.47 million square metres in 1900. About 95% of the total production was exported. This made Belgium into one of the global leaders of this industry.[1] Nevertheless, many aspects of the history of the Belgian window-glass industry are still not well-researched. These understudied aspects include the way the industrial district functioned as an organisational environment, the roles of the local business-interest organisations and the national government for the international promotion of Belgian window glass, and the way technological innovation related to traditional skills. One aspect that deserves particular attention is the way that geographical proximity (clustering) and knowledge were interrelated. Here, 'knowledge' refers to both explicit or codified knowledge (knowledge that can be literally 'written down', or at least communicated through language, 'know-what' knowledge) and tacit or embodied knowledge (skills and abilities acquired through practical 'hand-on' experience, 'know-how'-knowledge).[2] The situation of close geographical proximity influences the way both types of knowledge function, as it is believed to facilitate the exchange of 'old' (existing) knowledge and the creation of 'new' knowledge, both explicit and tacit.[3] The theoretical background of knowledge, including various types of knowledge and different knowledge-management strategies will be discussed in more details in the introduction to the Part 3. The practical methodology for the research on knowledge on the basis of sources available will be dealt with in the Part 3 as well.

The present study will address these (and other) questions in a comprehensive way, taking the 'industrial-district' theory as a main theoretical framework. This theory, first introduced by Alfred Marshall in the early 20th century and 'rediscovered' in the 1980s, is currently enjoying a global resurgence in interest in both historical and other research.[4] Much research

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[1] Yves Douxchamps, "L'évolution séculaire de l'industrie du verre à vitres et de la glacerie en Belgique de 1823 à 1913," *Bulletin de l'Institut de Recherches Économiques et Sociales* 17, no. 3 (1951): 512; Luc Engen, ed., *Het glas in België van de oorsprong tot heden* (n. p.: Mercatorfonds, 1989), 194.
[2] Sirje Virkus, "Tacit and Explicit Knowledge," Institute of Information Studies, Tallinn University, 2014. Key Concepts in Information and Knowledge Management. Accessed 19 June 2023. https://www.tlu.ee/~sirvir/Information%20and%20Knowledge%20Management/Key_Concepts_of_IKM/tacit_and_explicit_knowledge.html ; Jeremy Howells, "Tacit Knowledge, Innovation and Technology Transfer," *Technology Analysis & Strategic Management* 8, no. 2 (1996): p. 91-106.
[3] Jonathan Zeitlin, "Industrial districts and regional clusters," In *The Oxford handbook of business history*, ed. Geoffrey Jones and Jonathan Zeitlin (Oxford: Oxford University Press, 2008), 217-243; Fiorenza Belussi and Katia Caldari, "At the origin of the industrial district: Alfred Marshall and the Cambridge school," *Cambridge Journal of Economics* 3, no. 2 (March 2009): 335-355.
[4] Ibidem.

on historical industrial districts in a broad international context has been published recently.[5] One of the main advantages of the industrial-district approach, is the possibility for comparative research in a broad international context. This comparison is facilitated by two analytical models. The first model, introduced by Andrew Popp, Steve Toms and John Wilson (2006), provides a matrix for the organisational structure of industrial districts based on the combination of resources present in the district.[6] The second, the 'Modified Adaptive System' model by Ron Martin and Peter Sunley, provides possible trajectories for historical development of the industrial districts.[7] Both models will be discussed in more detail in the chapter on the theoretical background (Part 1, Chapter 1.1). While the present study is not comparative, the use of these models will allow for comparative research in the future, while also contributing to the better understanding of the Charleroi industrial district as an 'isolated' case. In the context of this study, the 'Charleroi industrial district' will refer to the window-glass industry (if not explicitly stated otherwise). It should be noted that this region was home to many other industries as well. It is not the purpose of this study to provide development trajectories of other industries located in this region. Yet, basic background on the development of the Charleroi industrial district as a whole is provided in Part 1, Chapter 1.3.

The choice of case and the delimitation of subject

The window-glass industry presents us with an interesting case of industrial development in the 19th century that transcends purely 'national' (Belgian) importance for various reasons. The leading global position of the Belgian window-glass industry during this period already affirms its importance for the international context. Moreover, the window-glass industry presents an interesting case in the context of the history of technological development and craftsmanship in the period of industrialisation. The existing literature generally describes the Belgian window-glass industry as 'traditional' due to the fact that manual skills and tacit knowledge of workers remained of paramount importance until the early 20th century.[8] However, as will be argued later, this craftsmanship was accompanied by very important technological innovations, many of which were developed in Belgium. My research on the relationship between 'traditional' craftsmanship and 'modern' technology within the window-glass production system will contribute to the ongoing discussion on the role of skills, craftsmanship and innovation during the industrialisation era, which can be traced back to the works of Maxine Berg and Pat Hudson, among others.[9]

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[5] John F. Wilson and Andres Popp, eds., *Industrial Clusters and Regional Business Networks in England, 1750-1970* (London and New York: Routledge, 2003); John F. Wilson, Chris Corker and Joe Lane, eds. *Industrial clusters: knowledge, innovation systems and sustainability in the UK* (London and New York: Routledge, 2022).

[6] Andrew Popp, Steve Toms and John Wilson, "Industrial districts as organisational environments: Resources, networks and structures," *Management & Organizational History* 1, no. 4 (2006): 349-370.

[7] Ron Martin and Peter Sunley, "Conceptualizing Cluster Evolution: Beyond the Life Cycle Model?" *Regional Studies* 45, no. 10 (2011): 1299-1318.

[8] Jean-Louis Delaet, "La mécanisation de la verrerie à vitres à Charleroi dans la première moitié du XXe siècle," In *L'innovation technologique. Facteur de changement (XIXe-XXe siècle*), eds. Ginette Kurgan-Van Hentenryk and Jean Stengers (Brussels: Éditions de l'Université de Bruxelles, 1986), 113-152.

[9] Maxine Berg and Pat Hudson, "Rehabilitating the Industrial Revolution," *Economic History Review* 45, no. 1 (1992): 24-50; Maxine Berg, "Revisions and Revolutions: Technology and Productivity Change in Manufacture in Eighteenth-Century England," In *Innovation and Technology in Europe, from the Eighteenth Century to the Present Day*, eds. Peter Mathias and John A. Davis (Oxford: Blackwell, 1991), 43-64.

The chronological limits of the study are set between 1830 and 1914. The reason for choosing this particular end limit is rather straightforward. Apart from the obvious political significance (outbreak of the First World War), the date marks a fundamental transition of the window-glass industry itself. It was during the First World War that the mechanical production of window glass was fully developed by Émile Fourcault (although the first installations were put into service shortly before). After the war, mechanical production soon replaced manual glassblowing, thus eliminating traditional skills and changing the entire production system completely.[10]

The choice of starting point was less straightforward, as the window-glass industry did not experience the same profound change in the early 19th century as it did one hundred years later. The political events (final defeat of Napoleon at Waterloo in 1815 and the Belgian revolution of 1830) did cause certain perturbations of the economy in general and the window-glass industry in particular, but these remained of limited influence.[11] Nevertheless, the steady quantitative growth of the window-glass industry began soon after 1830.[12] Some important innovations, such as new types of annealers and the use of artificial soda for glass production, were also introduced around or shortly after 1830.[13] Therefore, while being less straightforward than in 1914, the date of 1830 is significant as well beyond purely political reasons. Nevertheless, in some cases (for instance, to track long-term developments), this lower limit will be observed less strictly in this study. Another reason to uphold 1830 as a starting date (save for a few exceptions) is of a practical or methodological nature, as the source situation from before Belgian independence (and certainly from the *Ancien Régime*) is quite different. For instance, invention patents, which form an important source for this study, were only available from 1830 onwards.

Another delimitation concerns the product itself. The present study concerns window glass only, making it self-evident that the production of other types of glassware (bottles, vessels and so forth) is beyond the scope. The study will focus on the clear (that is, colourless) window glass with only occasional mention of the production of coloured window glass when it is relevant for the global research objective (for instance, how did the production of coloured glass influence the organisation of the window-glass industry in general?). The topic of the artistic production of stained glass will be omitted completely, as well as that of plate glass. In the 21st-century context, the terms 'window glass' and 'plate glass' are used synonymously. However, up to the mid-20th century, these were two distinct products, manufactured with distinct methods. The term 'window glass' was applied to glass produced

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[10] Catherine Thomas, "La société anonyme Brevets Fourcault: victime de guerre?" In *Composer avec l'ennemi en 14-18? La poursuite de l'activité industrielle en zones de guerre. Actes de colloque européen, Charleroi, 26-27 octobre 2017* (Brussels: Académie Royale de Belgique, 2018), 223-233; Francis Poty and Jean-Louis Delaet, *Charleroi pays verrier. Des origines à nos jours* (Charleroi: Centrale générale, 1986), 195-205.

[11] J. Mac Lean, "Gegevens over de Nederlandse en Belgische glasindustrie 1800-1850," *Economisch en sociaal-historisch jaarboek* 42 (1979): 107-155; Engen, *Het glas in België*, 193; Virgile Lefèbvre, *La verrerie à vitres et les verriers de Belgique depuis le XV^e siècle* (Paris and Brussels: Labor, 1938), 39.

[12] Douxchamps, "L'évolution séculaire de l'industrie du verre à vitres," 472-474.

[13] Poty and Delaet, *Charleroi pays verrier,* 47-49; Gustave Drèze, *Le livre d'or de l'exposition de Charleroi en* 1911 (Liège: Bernard, 1913), 450-453; Julien Maréchal, *La guerre aux cheminées. Pollutions, peurs et conflits autour de la grande industrie chimique (Belgique, 1810-1880)* (Namur: Presses Universitaires de Namur, 2016), 43-55.

by blowing. The term 'plate glass', on the other hand, referred to flat glass obtained by casting and subsequent polishing. This process resulted in a much better quality (flatness), yet it required much more energy for grinding and polishing (manual labour first, steam power later), and, hence, incurred a much higher price. When compared to the blown window glass, plate glass was an expensive luxury product.[14] The organisation of the plate-glass industry was completely distinct from that of blown window glass. The production process itself with grinding and polishing was very different from that of blown window glass.[15] As a result, these two branches of flat glass production developed independently from each other. The plate-glass industry developed its own structure with a few large factories.[16]

Concerning terminology, blown window glass was called *verre à vitre* in French, and plate glass was called *glace*. The term *verrerie* could signify an individual window glass factory as well as the entire blown window-glass industry, while the term *glacerie* could stand for an individual plate-glass factory or the entire plate-glass industry.

Research questions and methodology

The present study tackles three main research questions.

First research question: How can the concentration of the window-glass industry in a small region be explained? In other words, which factors were responsible for the clustering of the industry?

Second research question: Did this clustering cause specific governance structures and arrangements, such as specific production organisation, predicted by the theory of industrial districts? If discrepancies between the theory and factual outcomes are observed, which factors can be held responsible?

Third research question: Did the clustering provide specific conditions for the development of innovation, such as (collective) knowledge-management strategies and how was this related to craftsmanship?

In order to answer the first question, several topics need to be studied, whereby several sub-questions need to be addressed. To begin with, location factors and agglomeration externalities need to be examined. This will largely be based on the data concerning the origin and location of raw materials. As no quantitative sources on this matter were preserved in a systematic way, mostly qualitative sources will be used, such as mentions of the origin of raw materials recorded in requests for the establishment of factories, proceedings of the *Association des Maîtres de Verreries* (the business interest organisation of the Belgian window-glass industry) and some others. The research on the externalities will

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[14] Michael Cable, "The Development of Flat Glass Manufacturing Process," *Transactions of the Newcomen Society* 74, no. 1 (2004): 31-35.

[15] Poty and Delaet, *Charleroi pays verrier,* 53-55; Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*. Monographies Industrielles, Vol. IV (Brussels: J. Lebègue & C^{ie} and O. Schepens & C^{ie}, 1907), 61-66.

[16] Poty and Delaet, *Charleroi pays verrier,* 51-57, 117-121.

require more versatile analyses, as the concept of externalities itself is versatile and multifaceted. Externalities (or agglomeration effects) include various advantages resulting from the geographical proximity of enterprises. These can include, for example, shared resources, possibilities for cooperation between firms, input-output relationships between firms, and so forth.[17] My research on externalities will primarily include the study of trade directories (in order to reveal possible interdependencies between firms, such as input-output relationships) and the proceedings of the *Association des Maîtres de Verreries* (in order to research cooperation among firms).

The second research question mostly relates to institutions and organisations that facilitated the functioning of the industrial district. To begin with, the relevant institutions will be identified on the basis of existing literature. It can already be stated here that the *Association des Maîtres de Verreries* will be studied closely, as this organisation represented almost the entire window-glass industry and played a major role in its governance. The interrelations between the *Association des Maîtres de Verreries* and other institutions, such as the Chamber of Commerce, will be studied as well. Moreover, due to the very 'international' (that is, export-oriented) character of the Belgian window-glass industry, the developments in Belgium will be placed in the international context. For instance, international contacts and information exchange networks will be studied. To a large degree, these contacts and networks will be studied from the proceedings of meetings of the *Association des Maîtres de Verreries.*

The third research question concerns the way the specific organisation of the industrial district influenced knowledge-management and the development of innovation. To access this topic, the particular characteristics of the community will be explored first, as it was within the community that the knowledge was shared (or not) and innovations were developed. This can be done on the basis of existing literature. After this, the knowledge-management and innovation will be explored. Here, again, the *Association des Maîtres de Verreries* will be used as a source. In addition, a study of a sample of invention patents will be conducted. This sample study will be partly quantitative.

Historical research can be conducted according to various methodological approaches. Writing on this issue, Arturo Alexander Sánchez Molina and Angélica Murillo Garza distinguish three main paradigms or methodological alternatives: quantitative, qualitative and comparative. Hereby, these approaches should be regarded as complementary rather than mutually exclusive.[18] Principally, my research is of a qualitative nature. This is due to the fact that most data available from the sources is non-numerical. Yet the important aspects of innovation and knowledge-management will be partly studied in quantitative ways, by analysing a sample of invention patents.

Generally, qualitative research tends to favour inductive rather than deductive reasoning, as is it guided by the knowledge provided by various people (authors of sources) rather than by

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[17] John B. Parr, "Agglomeration economies: ambiguities and confusions," *Environment and Planning A: Economy and Space* 34, no. 4 (2002): 717-731.

[18] Arturo Alexander Sánchez Molina and Angélica Murillo Garza, "Enfoques metodológicos en la investigación histórica: cuantitativa, cualitativa y comparative," *Debates por la Historia* 9, no. 2 (2011): 148.

a hypotheses formulated by the external researcher.[19] Or, as formulated by Gordana Jovanović, the qualitative approach tends to prioritise subject matter over method.[20] This is not to say, of course, that the qualitative research should be conducted without any conceptual framework. As described above, the research will be guided by the specific research questions. The directed 'interrogation' of sources, combined with the understanding of their context (including limitations) such as, for instance, the social position and interests of authors (for example, the members of *Association des Maîtres de Verreries*, see more on sources and their criticism further) as well as the juxtaposition of various sources will allow to avoid being infulenced by the internal logic of sources rather than by the research objectives.

Moreover, the two aforementioned models (the Model of industrial districts as organisational environments by Popp, Toms, and Wilson and the 'Modified Adaptive System' model by Martin and Sunley, see further discussion in Part 1, Chapter 1.1) will be applied as 'tools' allowing for a better understanding of the historical changes of the district over time. They will provide a framework for the interpretation of various findings in a consistent and systematic way. In turn, this interpretation will help to answer the three research questions.

Historiographical context and literature review

The present study can be embedded in three main historiographical topics: the history of industrialisation in 19th-century Belgium with the window-glass industry as a specific case; the history of industrial districts as specific structures of business organisation; and the history of relationships between technological innovations and craftsmanship. In more general terms, these three topics can be perceived as belonging to the fields of economic history, business history and history of technology.

While not aiming to provide the historiography of these research traditions in any detail, the following sections will discuss the key works in each of them, in order to provide the necessary context.

History of the window-glass industry in the 19th-century Belgium has been described in several more general works on the history of glass in Belgium. First and foremost , it is impossible not to mention *L'Histoire de la verrerie en Belgique du IIe siècle à nos jours* by Raymond Chambon, published in 1955.[21] Upon its publication, this work became a standard monograph on the general history of glass in Belgium for several decades. However, later research has shown its unreliability in many respects. In particular, according to Janette Lefrancq, Chambon literally abused evidence, including the 'simulation' of archaeological evidence as well as the forgery of documents. While this instance considers the specific case of luxury glass production in the region of Chimay (southern Hainaut), it raises doubts about

[19] Ibidem, 154-155.

[20] Gordana Jovanović, "Toward a social history of qualitative research," *History of Human Sciences* 24, no. 2 (2011): 1.

[21] Raymond Chambon, *L'histoire de la verrerie en Belgique du II^{me} siècle à nos jours* (Brussels: Éditions de la librairie encyclopédique, 1955).

the reliability of Chambon's work in its entirety.[22] Apart from his magnum opus, Chambon had published a catalogue of an exposition on the history of the glass industry in the Charleroi region, *Trois siècles de verrerie au pays de Charleroi*.[23] Here, again, the utmost caution is required, as this work, while providing many historical details, cites almost no sources, making it almost impossible to use the information provided. A collective monograph *Glas in België* (edited by Luc Engen), or *Le verre en Belgique des origines à nos jours* (there are two editions, in Dutch and in French, I have used the Dutch edition) was published in 1989.[24] Various chapters were written by various authors.

In general, most works on the history of glass production in Belgium in the 19th century tend to focus on artistic production (stained glass, hollow glass, lead glass), while attention to the 'humble' clear window glass has remained limited. Moreover, most works, such as the two aforementioned standard monographs are of a descriptive nature. Nevertheless, two important exceptions – both dedicated to the window-glass industry specifically – are worth noting from the economics point of view: the monograph, *La verrerie à vitres et les verriers de Belgique depuis le XVe siècle* (1938) by economist Virgile Lefèbvre,[25] and an article 'L'évolution séculaire de l'industrie du verre à vitres de 1823 à 1913' (1951) by Yves Douxchamps.[26] The latter work is particularly valuable for its quantitative approach, as it provides a series of data on prices of glass as well as coal and raw materials. Yet both these works are far from recent and remain rather descriptive.

As for the regional approach, there exists a monograph on the Charleroi region, *Charleroi pays verrier* (1986) by Francis Poty and Jean-Louis Delaet for Charleroi, and another on the Centre *Histoire des verriers et des décorateurs sur verre de la région du Centre* (2009) by Daniel Massart, which is a new extended and improved edition of his first monograph *Verreries et verriers du Centre*, 1983.[27] Last but not least, two PhD theses are worth mentioning. The 'Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen in de Belgische Glas- en Textielnijverheid, 1886-1914' by Widukind de Ridder (2011), which concentrates on the comparative study of labour relationships and wage systems in the Belgian textile and glass industries;[28] and 'The look of window glass. A social and cultural history of clear window glass from the 15th to the late 19th centuries in the Scheldt-Meuse-Rhine-region', by

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[22] Janette Lefrancq, "La verrerie en Belgique de la Renaissance à la Révolution Industrielle," In *Histoire des techniques en Belgique. La période préindustrielle/Geschiedenis van de techniek in België. De pre-industriële periode,* eds. Robert Halleux, Jan Vandersmissen and Philippe Tomsin (Liège: Les éditions de la province de Liège, 2015), 505-552.

[23] Raymond Chambon, *Trois siècles de verrerie au pays de Charleroi* (Charleroi: Musée du Verre, 1969).

[24] Engen, *Het glas in België.*

[25] Lefèbvre, *La verrerie à vitres.*

[26] Douxchamps, "L'évolution séculaire de l'industrie du verre à vitres."

[27] Poty and Delaet, *Charleroi pays verrier*; Daniel Massart, *Verreries et verriers du Centre (de 1764 à nos jours)* (Haine Saint Pierre: Cercle d'Histoire et de Folklore Henri Guillemin, 1983); Daniel Massart, *Histoire des verreries et des décorateurs sur verre de la région du Centre* (La Louvière: Cercle d'Histoire Henri Guillemin, 2009).

[28] Widukind de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen in de Belgische Glas- en Textielnijverheid, 1886-1914" (Unpublished PhD thesis, Vrije Universtieit Brussel, 2010-2011).

Liesbeth Langouche (2022), which is dedicated to the history of window glass from a demand side and material culture perspective.[29]

My thesis will contribute to a better understanding of the history of the Belgian window-glass industry by moving beyond descriptive approaches, and by firmly embedding research results in the theoretical(-geographical) framework related to the history of innovation, technology and labour, as well as business organisation.

The *history of industrial districts as specific structures of business organisation* provides my main conceptual framework. As already mentioned, historians started to show interest in industrial districts from the 1980s onwards.[30] The lasting importance of this approach is attested to by a recently edited volume, representing a broad range of case studies of industrial districts.[31] More details on the historiography of industrial districts are provided in Part 1, Chapter 1.1 on the theory of industrial districts as business structure organisations. One concept which is closely associated with industrial districts is that of flexible specialisation. In particular, the concept was elaborated in a 1985 article by Charles Sabel and Jonathan Zeitlin, who explicitly associated it with Marshallian industrial districts. The concept postulates that many small and medium-sized firms, operating in close proximity within a district, could swiftly adopt their production assortment in response to changing tastes.[32] However, unlike most industrial districts researched to date, the Charleroi district was specialised in a rather 'generic' product that had fewer variations. Therefore, my research will provide a new perspective on the understanding of the way different types of industrial districts operate.

The *history of the relationships between technological innovations and craftsmanship* in the context of the industrial revolution has received much attention since the 1970s, as will be discussed in more detail in (Part 3, Chapter 3.3). In particular, already in 1977, Raphael Samuel argued that many industries remained 'traditional' (that is, based on manual labour rather than on the use of machines) until the very end of the 19th century.[33] From a quantitative perspective, the cliometric school of the 1970s and 1980s even questioned the validity of the concept of the Industrial Revolution itself, pointing to the fact that the adoption of steam power and other new technologies was much slower than previously assumed and limited to specific economic niches. Moreover, as pointed out later (1992) by Maxine Berg and Pat Hudson, the relationship between 'modern' industrial technology and 'traditional' skills was far from dichotomous. Intermediate forms, mixing 'new' and 'traditional' production methods, were the rule rather than the exception.[34]

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[29] Liesbeth Langouche, "The look of window glass. A social and cultural history of clear window glass from the 15th to the late 19th centuries in the Scheldt-Meuse-Rhine-region" (Unpublished PhD thesis, University of Antwerp, 2022).
[30] Zeitlin, "Industrial districts and regional clusters," 219-243.
[31] Wilson, Corker and Lane, *Industrial clusters.*
[32] Charles Sabel and Jonathan Zeitlin, "Historical Alternatives to Mass Production: Politics, Markets and Technology in Nineteenth-Century Industrialization," *Past & Present*, no. 108 (Aug 1985), 133-176.
[33] Raphael Samuel, "Workshop of the World; Steam Power and Hand Technology in mid-Victorian Britain," *History Workshop Journal* 3, no.1 (1977), 6-72.
[34] Maxine Berg and Pat Hudson, "Rehabilitating the Industrial Revolution," *Economic History Review* 45, no. 1 (1992), 24-50.

My research will contribute to this debate by focusing on an industry that has never attracted much attention in this context, although the tension and interaction between craftsmanship (manual skill) and technological innovation is its central characteristic. Indeed, the Belgian window-glass industry had been described as very traditional due to the fact that it remained dependent on highly skilled manual labour (glassblowing) until the early 20th century.[35] However, as will be shown below, technological innovation was very important even before the introduction of the famous Fourcault method. In order to understand the dynamic between tradition and innovation and to obtain a more balanced view, I will assess the roles of innovation as well as craftsmanship in order to contribute to our understanding of the process of technological innovation beyond simplistic dichotomies. As will be argued, far from being traditional the window-glass industry was characterised by a unique combination of technological innovation and craft tradition.

Sources

It is nothing short of a truism that company archives form the 'royal way' for the writing of business history. Blessed is the historian who has the luck to find a (more or less complete) archive of an enterprise(s) of their interest. However, it is an equal truism that most companies did not leave complete archives for historians to work with (quite often, bankruptcy cases present an exception). This does not make the writing of business history impossible, but certainly adds to the historian's challenge. A wide range of sources can still be used with success. These sources are to be found in the national and local archives, as well as in published form. The heterogeneity of these sources certainly makes the interpretation and the 'completion of a puzzle' challenging, as these were composed of very different actors (such as public authorities of different levels, for example) with very different objectives (taxation, legal actions, statistics, or even environmental concerns), therefore emphasising very different aspects. Yet, 'challenging' does not mean impossible.

The following provides an assessment of the most important types of sources that were used for the present study. Company archives will not be assessed, as they were not used. The only company archive that has survived with some degree of completeness, is that of the *Verreries de Mariemont*. Its General Assembly proceedings as well as some correspondence are preserved in the State Archives of Belgium (ARA-2, Depot Joseph Cuvelier). However, these do not provide any valuable information with respect to the objectives of my study. Several pieces from other firms are preserved in the Musée du Verre, yet they have also proved of little relevance.

The assessment of sources is based on several overviews by Nele Bracke, Hilde Greefs, Chantal Vancoppenolle, Patricia Van den Eeckhout and others, published as articles, chapters within books and one monograph.[36]

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[35] Poty and Delaet, *Charleroi pays verrier*, 113-130.

[36] Nele Bracke, *Bronnen voor de industriële geschiedenis. Gids voor Oost-Vlaanderen (1750-1945)* (Ghent: Academia Press, 2000); Nele Bracke and Hilde Greefs, "Puzzelen met bronnen. Een selectie van bronnen buiten het bedrijfsarchief voor de ondernemersgeschiedenis (19de eeuw)," *Belgisch Tijdschrift voor Nieuwste Geschiedenis* 23, no. 3-4 (2003): 357-398; Chantal Vancoppenolle, Joachim Derwael and Dirk Luyten, "De ondernemingen," In: *Bronnen voor de studie van het hedendaagse België, 19e-21e eeuw*, 2nd rev. ed., eds.

Not all potential sources were used, due to both conceptual and practical considerations. For instance, notarial records and the cadaster can be quite useful for the historical analysis of an individual enterprise. However, as mentioned in the introduction, my research concentrates on specific aspects of the window-glass industry in general, such as the governance structures (business interest organisations) and the development of technology, rather than on the histories of individual enterprises. Therefore, these sources were not used. Moreover, notarial records are especially notorious for their difficult accessibility, requiring very labour-intensive study processes, which was not possible in the scope of the present study.

Unpublished sources

The three main groups of unpublished sources that were used for the present study are the proceedings of the *Association des Maîtres de Verreries* (private archives Mr. Frédéric Gobbe, Charleroi), the requests for the establishments or changes of factories and machinery (State Archives of Belgium, municipal archives) and Invention patents (State Archives of Belgium-2, Depot Joseph Cuvelier).

Proceedings of the Association des Maîtres de Verreries (Private archives Frédéric Gobbe)

The most unique source used in this study undoubtedly consists of the proceedings of the *Association des Maîtres de Verreries* (hereafter referred to as the *Association*), the business interest organisation of the Belgian window-glass industry established in 1848 (more on this organisation in Part 1, Chapter 2.2). The complete series of proceedings from its establishment in 1848 until its disestablishment (last assembly held in 1927, formal disestablishment in 1932[37]) are kept by Mr Frédéric Gobbe (Charleroi). Mr. Gobbe (born in 1930) is an heir of the last President of the *Association*,[38] and decided to bequeath these documents to the State Archives of Belgium in Mons.[39] He allowed me to study the *Association*'s proceedings without limitations, for which I am very grateful.

The proceedings contain the reports from the *Association*'s meetings. While not being exact minutes (it seems rather that discussions were recorded in somewhat condensed form), they contain agenda items of each meeting. In some cases, when discussions emerged, the viewpoints of different members were recorded. Hence, the proceedings present a unique and very valuable treasure chest, which allows us to study the *Association*'s concerns and policies, and hence the evolution of the entire window-glass industry, for more than six decades (from 1848 up to 1914) without interruption. Still, like any other source, it is not

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Patricia Van den Eeckhout and Guy Vanthemsche (Brussels: Koninklijke Commissie voor Geschiedenis — Commission Royale d'Histoire 2009), 827-860; Patricia Van den Eeckhout, "Verder kijken dan het bedrijfsarchief: aanvullende bronnen op papier, "In: *Een succesvolle onderneming. Handleiding bij het schrijven van een bedrijfsgeschiedenis*, Algemeen Rijksarchief en Rijksarchief in de Provinciën Studia 104. Rev. ed., ed. Chantal Vancoppenolle, (Brussels: Algemeen Rijksarchief, 2005), 113-146; A. Thijs, "Gedrukte, geschreven en iconografische bronnen," In: *Industriële archeologie in Vlaanderen. Theorie en praktijk*, ed. Roland Baetens (Antwerp: Standaard Uitgeverij, 1988), 39-51.

[37] André Darquennes and Frédéric Gobbe, *Les verriers Schmidt au Pays de Charleroi* (Charleroi-Marcinelle: Association généalogique du Hainaut belge, 2006), 166.

[38] Private archives Frédéric Gobbe, Charleroi

[39] Mr. Frédéric Gobbe, personal conversation with author, 19 December 2022.

without its drawbacks. While some aspects (for instance, tariffs) were discussed on a regular basis, others were only touched upon sporadically at best. For instance, the question of technology started to appear on the *Association*'s agenda in the late 19th century only. Nor was everything recorded in this series. For instance, the proceedings sometimes referred to 'special reports' (for example, on some technological questions) that were recorded separately. Unfortunately, these special reports were not preserved. However, several extensive reports on the state of the window-glass industry were included in the proceedings, providing valuable information.

Moreover, it is clear that this source presents only the employers' perspective, which is particularly relevant for any labour-related issues mentioned in the proceedings. The labour movement was described as 'the greatest threat to the industry' on multiple occasions. Hence, social issues mentioned should be seen within the context of the struggle between capital and labour, whereby the source at our disposal evidently represents the position of the former. This is of somewhat lesser importance with respect to the objectives of the present research, as it does not focus on the social issues primarily, yet this fundamental limitation should be kept in mind.

Furthermore, the source represents the perspective of a collectivity rather than that of individual firms and entrepreneurs. Even if the views of various entrepreneurs were recorded on multiple occasions when discussions arose, the proceedings tell us almost nothing about the history of individual enterprises. While the organisation of labour (including apprenticeship, for instance) in different firms was mentioned on several occasions, other important topics, such as machinery and equipment used by various firms were never touched upon.

Last but not least, the fundamental question of representativeness should be addressed. Upon its establishment in 1848, the *Association* (called *Comité* at that time) united smaller firms mostly. It was only in the course of the next decades, by the last quarter of the 19th century, that almost all the enterprises joined, including the very largest, *Bennert & Bivort*. While it represented almost the entire Belgian window-glass industry from that moment on, a few 'dissidents' remained outside the *Association*.

Requests for permissions

Requests for the establishment of 'harmful enterprises'

In 19th-century Belgium, the establishment of 'harmful enterprises' (*établissements dangereux, insalubres et incommodes*) required a specific permission, delivered by either national, regional (provincial) or local (municipal) authorities. Already in 1789-1790, local authorities were granted legal powers concerning 'public cleanliness and health' by French decrees. These powers allowed communes to subject enterprises to regulations on environmental issues. The first national legislation on this issue was introduced by a Napoleonic decree of 15 October 1810. According to this decree, enterprises 'spreading unhealthy and unpleasant odours' were obliged to request a permission before establishment in a particular location. In 1824, the 1810 decree was replaced by a Royal decree, which was applicable to all enterprises that could 'pose danger, damage or hindrance for the public'. The 'Dutch' legislation of 1824 was in turn replaced by a new Belgian Royal Decree of 1849, while retaining its basic principles. Hence, such 'harmful enterprises' were required to receive a permission before their establishment. The preliminary investigation (known as *commodo-incommodo*) was carried out by authorities (national or local, depending on the 'level of dangerousness', that is, potential risk posed by an enterprise). The new law prescribed in more detail the elements each demand had to contain, such as the purpose of the enterprise, as well as the production methods used and the quantity of (projected) production. The 1849 legislation was slightly modified in 1863. From that moment on, only provincial and municipal authorities were competent for the granting of permissions. National authorities (the Ministry of Internal Affairs) were no longer involved.[40]

Requests for the establishment of steam installations

The 1824 legislation obliged separate permissions for the operation of steam installations. Alongside a preliminary investigation (*commodo-incommodo*), the installations had to be tested under the supervision of public authorities. These requests had to mention technical details such as the manufacturer of the installation and the power of the steam engine (horsepower). In 1839, new legislation on steam installation was passed, whereby permission was made mandatory before the installation of steam machinery (previously, the permission was required before the operation of steam machinery). In 1849, the legislation on steam machinery was modified, whereby a more detailed technical file, including drawings and plans of the installation, was required.[41]

Location and preservation of requests for permissions

Generally, requests for permissions are to be found in the archives of public authorities, either national, provincial or local. For the window-glass industry, two locations were identified: the State Archives of Belgium, and the Municipal Archives of Charleroi.

The State Archives of Belgium in Brussels contain a series of request files within the Administration des Mines series. This series contains dozens of files for the establishment of new factories or the expansion (such as construction of new furnaces) of already existing factories, dating from the early 19th century up to 1850. The oldest files, from around 1810, even pre-date Belgian independence. No files dated beyond 1850 are to be found in the State Archives. Most probably, this is due to the change of legislation in 1849.[42]

The files preserved in the State Archives typically contain a request by owner(s) with a short description of a factory and its equipment (furnaces and annealers almost exclusively) alongside the projected production and consumption of fuel and raw materials. In some cases, additional details, such as the number of workers, were recorded as well. The series appears to be rather complete. At any rate, it contains files related to most of the glass

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[40] Bracke, *Bronnen voor de industriële geschiedenis*, 242-251; Bracke and Greefs, "Puzzelen met bronnen," 374-376; Patricia Van den Eeckhout, "Verder kijken dan het bedrijfsarchief," 129-131; Thijs, "Gedrukte, geschreven en iconografische bronnen," 43.

[41] Bracke, *Bronnen voor de industriële geschiedenis*, 242-251; Bracke and Greefs, "Puzzelen met bronnen," 375; Patricia Van den Eeckhout, "Verder kijken dan het bedrijfsarchief," 131-132.

[42] State Archives of Belgium, Brussels, Administration des Mines, ancien fonds.

factories known to have existed at that time from other sources. Yet, some rate of omission cannot be ruled out. Interestingly, the series does not contain any negative outcomes (that is, cases whereby permissions were not granted). It is difficult to judge whether requests for the window-glass factories were always granted, or whether rejected files were not preserved.

For the period after 1850, request files are to be found in the municipal archives of Charleroi (*établissements classés* series), as the surrounding communes that housed most window-glass factories, such as Jumet and Lodelinsart, were merged with Charleroi in 1977.[43] However, the preservation of requests within the municipal archives is rather fragmentary. For instance, no files for Lodelinsart dating from before 1914 were preserved. Most of the files preserved in the municipal archives concern the steam installations rather than the factories themselves. These files contain inspection reports alongside technical specifications of the installations (steam boilers in most cases).

Hence, while the files preserved in the State Archives in Brussels and the Municipal Archives of Charleroi do not allow for a quantitative approach due to omissions, they are a very useful source with respect to the technological aspects of glass production, such as the layout of factories and furnaces, the raw materials used and the machinery employed.

Invention patents

Within the approach of the present study, invention patents play a dual role, as they are regarded both as a source of the development of the technology, and as one of the knowledge-management devices to be examined as part of business strategies. In this context, the Belgian patenting system is discussed in more detail in Part 3, Chapter 3.2. In this paragraph, only a brief assessment of invention patents as a source will be provided.

The ‘modern’ patenting legislation, which replaced the privileges of the Ancien Régime, was introduced in present-day Belgium in 1785, when it was annexed by France. The French patenting law was introduced in 1791. This law made a distinction between the *brevet d’invention* (for new inventions), the *brevet de perfectionnement* (for the improvement of technologies, mostly issued for the further development of already patented inventions), and the *brevet d’importation* (for the introduction of foreign inventions in France). In 1817, this French law was replaced by a new patenting law of the United Kingdom of the Netherlands, yet the new law upheld most of the basic principles of the old, such as the distinction between the *brevet d’invention*, *brevet de perfectionnement*, and *brevet d’importation*. This ‘Dutch’ law was replaced by a new law in 1854, still maintaining the aforementioned distinction. The 1854 legislation significantly lowered the threshold for patenting, as the patenting fee was decreased while the patent duration was increased. This resulted in a steady rise in the number of patents granted, and, arguably, a certain ‘democratisation of invention’. Because of this, only sample studies of patents after 1854 were possible within the context of the present research.

From 1830 to 1854, patents were published in the official inventory called the *Catalogue des brevets d’invention.* From 1854 onwards, this was replaced by the *Recueil des brevets*

[43] Municipal Archives Charleroi, Établissements classés.

d'invention publié en execution de l'art. 20 de la loi du 24 mai 1854. The *Recueil* published only a short description of the invention, while the complete dossier can be consulted in the archive.[44]

The patent files themselves are preserved in the State Archives of Belgium 2 – depot Joseph Cuvelier (Brussels).[45] Each file contains a number of standardised parts. First, the title page mentioned all administrative data, such as the name of the patentee (in some cases, his representative as well), the date and the place (geographical location), and a short description of the invention. Most invention patent files include detailed drawings as well.[46]

The main advantages and drawbacks of invention patents will be discussed further in Part 3, Chapter 3.2. In any case, patents attest to the general state of technology and enable reconstruction of the general paths of development. In some cases, patent files contained entire multi-page treatises, in which patentees reflected on the present state of technology and how their invention could improve the situation. Most patentees preferred to keep it short, however, presenting the (required) brief description of their invention only. Moreover, it should be kept in mind that most inventions were never put into practice, while many 'traditional' techniques employed in practice were not reflected in patents (at least not directly). At any rate, a thorough study of patents can reveal which problems were experienced at the time, even if not all the solutions proposed (that is, the patented inventions themselves) were put into practice. For instance, if a certain technical problem appeared in the patents time and again, we can be pretty sure that this reflected a real problem, even if most of the solutions (inventions) presented in the patents proved to be fruitless.

Another important use of patents as a source in this study relates to the way they were employed to share, spread and protect knowledge. For instance, it can be deduced from the patents what kind of knowledge was patented (and what not), making it possible to draw important conclusions on the way the professional community functioned. This will contribute directly to the third research question of my research: the way knowledge was managed.

[44] Liesbeth Dekeyser, Quentin Collette and Maaike van der Tempel, "Twee eeuwen Belgische brevetten: getuigen van innovatie en bouwtechnieken," *Erfgoed industrtie en techniek* 23, no. 2 (nov. 2014): 4-16; Paul Servais, "Les brevets d'invention en Belgique de 1854 à 1914," In Vol. 2 of *LI^e Congrès de la Fédération des cercles d'archéologie et d'histoire de Belgique et 4^e Congrès de l'Association des cercles francophones d'histoire et d'archéologie de Belgique. Liège 20-23 VIII. 1992. Actes* (Liège: n. p., 1994), 360-377; Michel Oris, "Inventivité technique et naissance d'industrie innovative en Belgique, 1860-1910," In *Technology and Engineering*, eds. M. Lette and M. Oris, Vol. VII of *Proceedings of the XX^th International Congress of History of Science, Liège 20-26 July 1997* (Turnhout: Brepols, 2000), 139-162; Corentin de Favereau and Arnaud Péters, "Vers une histoire du système belge des brevets au XIX^e siècle," In *Innovations et transferts de technologie en Europe du Nord-Ouest aux XIXe et XXe siècles*, eds Pierre Tilly and Jean-François Eck (Brussels: Peter Lang, 2011), 53-67.
[45] State Archives of Belgium 2 – depot Joseph Cuvelier, Brussels, Brevers d'inventions.
[46] Bracke, *Bronnen voor de industriële geschiedenis*, 268-272; Patricia Van den Eeckhout, "Verder kijken dan het bedrijfsarchief," 141-142.

Other

Alongside these three main source corpuses (Proceedings of the *Association*, requests, and invention patents), some other unpublished sources were used. In particular, the Musée du Verre (Glass museum, a part of the industrial heritage and memorial site of Bois du Cazier in Charleroi) holds a collection of diverse documents related to the glass industry in Belgium. Of these, the price lists of various manufacturers are particularly interesting, as they provide valuable information on the properties (such as sizes) of window glass.[47]

Published sources

Press

As will be discussed in more detail in Part 3, Chapter 3.2, no specialised trade press related to the glass industry existed in Belgium before the First World War. Some information could be found in the local press, such as *Journal de Charleroi* and *Moniteur Industriel de Charleroi*. In the early 20th century, several long articles on the economic situation of the Belgian glass industry were published in Belgian journals, for instance by H. De Nimal (1904), O. Misonne (1905) and A. Lalière (1913).[48]

Industrial censuses

Between Belgian independence and the First World War, national industrial censuses were conducted in Belgium by the Central Commission of Statistics (*Commission centrale de statistique*, established in 1843, the present day National Institute of Statistics) in 1846, (1866 – the results of this census were never published), 1880, 1896 and 1910.[49]

The published data of the 1846 and 1880 censuses did not distinguish between different branches of the glass industry, making it as good as useless for the present study. Luckily, the censuses of 1896 and 1910 were of more use.[50] As the data were presented by location rather than by individual enterprise, the industrial censuses inform us only about the general trends within the industry, and not about the history of individual firms. In particular, they provided valuable information on the use of steam power in the window-glass industry.

Treatises

As will be discussed in more detail in Part 3, Chapter 3.2, no treatises on glass production were published in Belgium in the 19th century. Various foreign 19th-century treatises,

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[47] Archives Musée du Verre, Charleroi, Divers.
[48] H. De Nimal, "L'industrie du verre à vitres en Belgique et la crise actuelle," *Revue Économique Internationale* 1, no. II (June 1904): 147-159; O. Misonne, "La crise verrière dans le bassin de Charleroi," *Revue Sociale Catholique* 9 (1904-1905): 33-42, 65-71, 129-137; A. Lalière, "Le verre en Belgique," *Revue Économique Internationale* 10, no. II (1913): 598-634.
[49] Bracke, *Bronnen voor de industriële geschiedenis*, 178-193.
[50] Ministère de l'Industrie et du Travail. Office du Travail, *Recensement général des industries et des métiers (31 octobre 1896)* (Brussels: Hayez, 1900-1902); Ministère de l'Industrie et du Travail. Office du Travail. *Recensement de l'industrie et du commerce (31 décembre 1910)* (Brussels: Lebègue, 1913-1921).

including the 1868 *Guide du Verrier* by Georges Bontemps[51] (probably the most influential work on the glass technology of the 19th century[52]) were used as a source of information on 19th-century glass technology in general.

In 1907, an important monograph on the Belgian glass industry called *Fabrication et travail du verre*, was published by the Belgian government as a part of the *Monographie industrielle* series.[53] The purpose of this book was to provide an overview of all aspects of the glass industry, including technology. Unlike the treatises such as that of Bontemps, it was not intended as a practical handbook on glass technology. Rather, it was meant to provide information on the state of the industry.

Catalogues and reports from expositions (fairs)

Numerous industrial expositions, organised on a regional, national and even international scale (World fairs, starting with the Great Exhibition of London in 1851) were typical of the 19th century. They resulted in two main types of publications: catalogues and reports. Catalogues provided lists of participants and their products, while reports contained more detailed descriptions, often focusing on a specific industry.[54] Both types were used for the present study. For instance, catalogues from various expositions proved to be quite informative with respect to the properties of glass (such as sizes) or various kinds of coloured glass that were produced by different Belgian firms. At the same time, some reports, such as that of the 1873 Vienna World Fair, provided interesting accounts of the developments of the glass industry in an international context, including the technology, for instance.[55] An account of the 1911 Charleroi exposition provided an extensive report on the state of the Belgian glass industry.[56]

[51] Georges Bontemps, *Guide du Verrier. Traité historique et pratique de la fabrication des verres, cristaux, vitraux* (Paris: Librairie du dictionnaire des arts et manufactures, 1868)
[52] Michael Cable, "The classic texts of glass technology," *Glass technology: European journal of glass science and technology. Part A* 54, no. 2 (2013): 57-65.
[53] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre.*
[54] Bracke, *Bronnen voor de industriële geschiedenis*, 323-326.
[55] Victor De Luynes, *Exposition universelle de Vienne en 1873 – Rapport sur la céramique et la verrerie* (Paris: Imprimerie Nationale, 1875).
[56] Drèze, *Le livre d'or de l'exposition de Charleroi.*

Part 1: Background and Context

The first part of this thesis mostly provides background and contextual information necessary for the better understanding of the two following parts, which are to be regarded as the core of the thesis: Part 2, on the organisation and functioning of the glass-producing industrial district, and Part 3, on the knowledge, innovation and craftsmanship within the window-glass district. Nevertheless, Part 1 already contains original research, in particular in the chapter on the general developments of the Belgian window-glass industry in the 19th century.

The Chapter 1.1 of Part 1 provides an assessment of the theory of industrial districts, that being the main theoretical framework of the entire thesis. The Chapter 1.2 then provides a general overview of the economic history of Belgium in the 19th century, in order to allow for a better understanding of the position of the window-glass industry within the national economy. The regional dimension receives particular attention, as the economic development of Belgium was very much region-based. Subsequently, the Chapter 1.3 discusses the development of the regions of Charleroi and the Centre in more detail, as it was these two regions that housed almost the entire Belgian window-glass industry. Chapter Four then describes the general developments of the Belgian window-glass industry, thus providing the necessary context for the more analytical discussion of various aspects of the window-glass industry in Parts 2 and 3. The Chapter 1.4 already contains important pieces of original research, based on published and unpublished sources. The Chapter 1.5 finally discusses the geographical distribution of window-glass factories on the regional scale.

Chapter 1.1: The theory of industrial districts as business structure organisation

Over the course of more than three centuries, from the early 17th century until after the First World War, the concentration within a relatively small region around the city of Charleroi remained the main defining feature of the Belgian window-glass industry. Despite some earlier exceptions, the decentralisation of this industry to other parts of Belgium only became prominent after 1918, which is beyond the scope of the present study.

The phenomenon of geographical concentration of industries and other economic activities has attracted a great deal of attention, starting with Alfred Marshall in 1890. Yet there is no exact definition of what an industrial district is, nor is there a single 'industrial-district' theory. The industrial district should rather be understood as an evolving concept, upon which various theories and models have been built over the course of decades. The following paragraphs describe the evolution of the concept over the last century, as well as some useful concepts that have been developed in related fields, and can be integrated within the industrial-district concept. At the end of the chapter, two recent models are discussed: the 'Model of Industrial Districts' as organisational environments by Popp, Toms and Wilson (2006),[57] which will hereafter be called 'the four-quadrant model'; and the 'Modified Adaptive System' model by Martin and Sunley (2011).[58] These two models will form the theoretical foundation for the subsequent research, as they can explain the evolution of the district (emergence, growth, crisis and transformation) based on a number of parameters,

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[57] Popp, Toms and Wilson, "Industrial districts as organisational environments."
[58] Martin and Sunley, "Conceptualizing Cluster Evolution."

such as raw materials, financial and human resources needed, and innovative activities, that will be examined further. In this way, the history of the district will move from the descriptive to the analytical stage. Moreover, these models allow for comparison with other cases known from the literature, such as the North Staffordshire Potteries, and hence allow the present study to be embedded in the already existing body of international research – thus providing opportunities for comparative research in the future.

As for now, a rather provisional definition of an industrial district can be given as a geographical clustering of firms that provide similar products and services and/or form a value production chain. Here, the external economies of scale (or externalities for short) of various kinds are the defining feature. Economies of scale are cost advantages that occur with the increase in production, as fixed costs can be spread over a larger number of produced goods. For example, a higher degree of labour division (and, hence, efficiency) can be achieved within a larger production unit. Economies of scale can be internal or external. Internal economies of scale are due to the larger size of a single firm, while external economies of scale result from scale advantages that occur outside individual enterprise and can be shared by multiple firms. For instance, several smaller firms can establish a joint research & development department, thus sharing the cost. A transportation network is another example of an external economy of scale, as multiple firms can use the same network (provided it is not saturated), thus dividing the costs.[59]

One of these externalities that deserves special mention is the development of knowledge and innovation within a cluster. This is because industrial districts are much more than just the geographical clustering of enterprises. Rather, they should be understood also as truly interdependent business organisation structures, as well as knowledge communities.[60]

Industrial district: Development of the concept

The origin of the concept: Alfred Marshall and the Cambridge School

The concept of the industrial district originates with Alfred Marshall, a prominent neoclassical Cambridge economist. It was first explicitly discussed in his *Principles of Economics* (Book IV, Chapter X Industrial Organization, Continued. The Concentration of Specialized industries in Particular Locations), which was first published in 1890 and ran to multiple editions in the following decades. Marshall's later work, *Industry and Trade* (first published in 1919), made further use of this concept.

Marshall starts his discussion of industrial districts in *Principles of Economics* with the causes of 'primitive localisation', that is, the initial reasons for the industries to settle in a certain location even before the emergence of a true industrial district. Of these, physical conditions

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[59] Will Kenton, "Economies of Scale: What Are They and How Are They Used?" Investopedia, updated 11 June 2022, accessed 06 April 2023, https://www.investopedia.com/terms/e/economiesofscale.asp ; Troy Segal, "External Economies of Scale: Definition and Examples," Investopedia, updated 30 November 2020, accessed 06 April 2023, https://www.investopedia.com/terms/e/externaleconomiesofscale.asp

[60] Summarising from: David Charles, "The evolution of business networks and clusters," In *Industrial clusters: knowledge, innovation systems and sustainability in the UK*, eds. John F. Wilson, Chris Corker and Joe Lane (London and New York: Routledge, 2022), 32-55.

assumed a prominent role. They include the character of climate and soil, the presence of natural resources, such as fuel for iron industry and clay for pottery, as well as easy access by land and water. Another 'primitive localisation' factor mentioned by Marshall is the patronage of (royal and noble) courts, that created demand for goods and sometimes deliberately introduced certain industries and attracted artisans.[61]

With time, a 'compound localisation' develops out of 'primitive localisation'. Or, as Marshall had described it himself: 'When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organisation of the business have their merits promptly discussed: if one man starts a new idea, it is taken by others and combined with suggestions of their own; and thus it becomes the source of new ideas. And presently subsidiary trades grow up in the neighbourhood, supplying it with implements and materials, organising its traffic, and in many ways conducting to the economy of its materials.'[62]

This quote, while being (admittedly) lengthy, already gives the main advantages (or positive externalities) of industrial districts in concise form. The fact that 'children learn the mysteries of trade unconsciously' can be interpreted as a specialised 'hereditary' skill or know-how that is transmitted between generations, although the level of 'unconsciousness' of this process is a matter of discussion. The collective development and implementation of inventions and improvements already foreshadows the role of industrial districts as knowledge communities and innovation hubs. The 'subsidiary trades' refer to the input-output linkages and division of labour. Further on in the chapter, Marshall discusses the use of specialised machinery emerging from the division of labour and the development of local markets for a special skill within the district.

However, Marshall mentions negative externalities of industrial districts as well. If an industrial district depends on a single industry only, it becomes vulnerable to the vicissitudes of markets such as falls in demand for its main product, or possible uncertainties with regard to the supply of its main raw materials. Moreover, labour markets might become too unbalanced, as was often the case in iron industries, where great physical strength was required, thus limiting employment opportunities for women and children.[63]

In his other works, including *Industry and Trade*, Marshall dedicates more attention to the role of interactions between firms within industrial networks. According to him, firms within industrial districts engage in competition and cooperation at the same time. The first important point is that the industrial districts are especially favourable to small and medium-sized firms. Within a district, these firms can develop common external economies. Large firms, on the other hand, can develop internal economies, so that they are less dependent on interactions with others.[64] To provide an example, if one small firm were not able to

[61] Alfred Marshall, *Principles of Economics*. 8th ed. (London: Macmillan and Co, 1936 [1st ed. 1890]), 267-269.
[62] Ibidem, 271.
[63] Ibidem, 267-277; Belussi and Caldari, "At the origin of the industrial district," 336-338.
[64] Belussi and Caldari, "At the origin of the industrial district," 338-340.

finance its own research & development department, multiple small firms within the same industry could finance a common research & development programme, or share knowledge in a more informal way (external economies). In this way, multiple small firms would be able to reach the same results as one large firm with its own research & development department (internal economies). The same logic can be applied to the training of the workforce and so forth.

Next, the question of cooperation comes to the fore. To quote from *Industry and Trade*, 'The broadest, and in some respects most efficient forms of constructive cooperation are seen in a great industrial district where numerous specialised branches of industry have been welded almost automatically into an organic whole [my own emphasis – V. V.].'[65] The quote indicates two important points. First, Marshall makes clear that he considers industrial districts as an environment that is mostly conducive to the cooperation between firms. Second, he mentions that this cooperation occurs 'almost automatically'. This 'automatic organisation', as discussed by Marshall, using the example of the British textile industries (that of Lancashire in particular), should be interpreted as a result of the multitude of smaller steps towards the division of labour and standardisation of production carried out by various actors (firms) without any large-scale global master plan. Nevertheless, Marshall dedicates attention to conscious collaboration as well. He discusses industrial associations (employers' associations or business interest associations) and their various functions, such as the regulation of prices, quality control, the supply of raw materials and so forth. Another interesting point discussed by Marshall refers to the benefits of standardisation across the firms within the district.[66] Interestingly, Marshall emphasises the role of such associations as an 'agent for the dissemination of knowledge of technique, and even for its advancement, in so far as that can be done by team-work.'[67] This observation already foreshadows theories of collective invention, that would only be developed many decades after Marshall's work (see the chapter on technology later in this thesis).

Summarising, three types of 'Marshallian externalities' (specialisation externalities) can be distinguished: 1) input-output transactions (division of labour between various firms, whereby different firms take a different place within the product production chain), 2) labour market pooling, and 3) technological externalities (the joint development of innovations and knowledge spillovers between similar firms).[68]

After Alfred Marshall, the concept of industrial districts was applied in research by some economists at Cambridge, forming the so-called 'Cambridge School' until the 1960s.[69]

Developments in related fields

After the initial development by Marshall and the Cambridge School, the concept lay largely 'dormant' for many decades. Writing in retrospect in 2008, Jonathan Zeitlin mentioned that

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[65] Alfred Marshall, *Industry and Trade* (London: Macmillan and Co, 1919), 599.
[66] Ibidem, 599-619; Belussi and Caldari, "At the origin of the industrial district," 340.
[67] Marshall, *Industry and Trade*, 607.
[68] Nicholas Alfred Phelps, "Clusters, Dispersion and the Spaces in Between: For an Economic Geography of the Banal," *Urban Studies* 41, no. 5/6 (May 2004), 973.
[69] Belussi and Caldari, "At the origin of the industrial district," 343-346.

the concept had been 'long forgotten' before the 1980s.[70] This might have been something of an exaggeration, but the concept certainly was not top on the research agenda for a long time. Meanwhile, many relevant concepts and approaches were developed in related fields, such as economics in general, business and innovation studies, economic geography and so forth. While most of them were developed outside of the Marshallian tradition, they are worth mentioning here, as they can contribute greatly to our understanding of industrial districts. Many of these concepts and approaches were integrated into the research on industrial districts from the 1980s onwards.

It would be impossible to discuss all relevant concepts in great detail, as they stem from various research fields and traditions. The detailed study of each of these disciplines is beyond the scope of the present study. Therefore, this paragraph is mostly based on overviews rather than on original papers, focusing only on the most prominent examples of each discussed concept or approach.[71]

Agglomeration effects and external economies

The agglomeration effects and external economies had already occupied a key place within Marshall's original theory. After all, without external economies, the clustering of firms would provide no advantages, thus making the whole concept pointless. Even when Marshall's concept itself temporarily fell out of fashion, research on agglomeration effects continued within other frameworks.

In very basic terms, agglomeration economies (or agglomeration effects) can be defined as cost advantages that result from the geographical concentration of enterprises in a certain location. A basic twofold classification, as presented by John B. Parr, includes both internal agglomeration economies and external agglomeration economies. In the former case, an example of spatial concentration of various production stages and processes within one firm can be provided, showing how, for instance, a layout of a production facility can reduce internal transport costs. In the latter case, agglomeration economies are beyond the scope of an individual firm. Examples can include shared resources, possibilities for cooperation between firms, input-output relationships between firms, and so forth.[72]

A new perspective on externalities was presented in *The Economy of Cities* (1970) by Jane Jacobs. Jacobs emphasised the positive externalities arising out of interactions between *different* industries, while the Marshallian externalities comprised advantages due to the concentration of *similar* industries. Hence, the *Jacobean externalities* are *diversification externalities*, while *Marshallian externalities* are *specialisation externalities*. As highlighted above, the Marshallian externalities comprise input-output transactions, labour market pooling and technological externalities. The Jacobean externalities should rather be thought of as knowledge spillovers between different industries. This is not to say that the Marshallian framework misses the knowledge component (which is present as technological externalities). Yet the Jacobean framework puts the knowledge component at the forefront. Moreover, it should be especially noted that specialisation and diversification are not

[70] Zeitlin, "Industrial districts and regional clusters," 219-220.
[71] Charles, "The evolution of business networks and clusters," 32-55.
[72] Parr, "Agglomeration economies: ambiguities and confusions," 717-731.

mutually exclusive. For example, a given city or region can have a diverse economic structure with multiple industries, while housing a larger part of one specific industry at the same time. The economic structure of such a city or region will thus be *diversified* and *specialised* at the same time.[73]

The distinction between Jacobean and Marshallian externalities caused an ongoing debate about whether the former or the latter are more beneficial to economic growth. No conclusion has yet been reached on this matter, but a recent paper, taking the development of US cities between 1880 and 1930 as an example, concluded that the increase in labour productivity overall was largely due to Marshallian (specialisation) externalities. Only in the largest cities, such as Chicago, Philadelphia and New York (all well above one million inhabitants circa 1900), did Jacobean (diversification) externalities result in rising productivity. Even more remarkable, in smaller cities diversification of the economic structure actually *reduced* productivity gains over the period. It should be emphasised, however, that this study is based on the example of one country during one period only and should not be generalised. Nevertheless, it seems plausible that Jacobean externalities are less likely to emerge in smaller cities and regions.[74]

Innovation and knowledge, institutions and organisations

The complex relationship between innovation and knowledge on the one hand and institutions and organisations on the other, all within the context of geographical proximity, received increased attention after the publication of the highly influential book *The Competitive Advantage of Nations* (1990) by Michael E. Porter. While the focus of this book is national rather than regional, the discussions it caused have yielded important insights that can be of use for the study of industrial districts as well. Specifically, the concept of the regional innovation system (RIS) came to the fore, albeit largely outside the 'Marshallian tradition'. It developed out of the older concept of the national innovation systems. Within the RIS approach, the role of regional-level institutions is stressed, especially in the context of reducing uncertainty, promoting collaboration and providing incentives for innovation.[75]

Applying the same logic to the industrial-district setting, the role of institutions for the functioning (and success) of the district comes to the forefront. Moreover, the institutionalist approach enables us to take a closer look at the interactions between regional institutions, such as local business associations, and national ones, such as those involved with patent legislation. This allows us to arrive at a more balanced view concerning the specificity of a given industrial district in relationship to the broader national context. The question of whether institutions were conducive (or not) to innovations is particularly important, as innovations played a crucial role in the ability of industrial districts to renew themselves, as

[73] Gerben van der Panne, "Agglomeration externalities: Marshall versus Jacobs," *Journal of Evolutionary Economics* 14 (2004): 593-604; Joseph Peter Lane, "Networks, Innovation and Knowledge: The North Staffordshire Potteries. " (Unpublished PhD thesis, The London School of Economics and Political Science, 2017), 36-38.

[74] Alexander Klein and Nicholas Crafts, "Agglomeration economies and productivity growth: US cities, 1880-1930," School of Economics Discussion Papers, No. 1574, University of Kent, School of Economics, Canterbury (2015).

[75] Charles, "The evolution of business networks and clusters," 32-55.

they adapted to the evolving circumstances according to the Modified Adaptive System models (see further).[76] In general, institutions can direct resources towards innovations, thus being conducive to innovations. On the other hand, rigid institutions can effectively slow down the pace of innovation, resulting in the so-called 'institutional sclerosis'.[77]

The concept of institutions came to the fore within the New Institutional Economics (NIE) from the 1970s on. Within the NIE conceptual framework, transaction costs (costs bound to economic transaction, such as costs for the acquisition of information, costs for the negotiations between parties of economic exchange, costs for ensuring agreements, such as legal contracts, property rights, etc.) played the key role. Institutions are regarded as a framework within which economic actions take place. Therefore, institutions define transaction costs to a large degree.[78]

The concept of institutions is extremely wide. It encompasses government bodies and private organisations of all kinds, universities and firms, as well as less tangible things, such as laws, traditions, and habits. Charles Edquist and Björn Johnson propose a twofold classification. They reserve the term 'institution' for the patterns of behaviour only, and define them as follows: 'Institutions are sets of habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups.' As for the 'institutions as concrete things', they prefer to call them 'organisations' rather than institutions (although they acknowledge that many institutional economists do now follow this distinction, using 'institutions and organisations' as synonyms), and define them as follows: 'Organisations are formal structures with an explicit purpose and they are consciously created. They are players or actors.'[79]

As for the former type of institutions (institutions as patterns of behaviour) they further distinguish between 'formal' (laws) and 'informal' (customs and traditions) institutions; 'basic' (constitutional rules) and 'supporting' (some specific restriction or by-laws) rules, and 'hard' (binding and mandatory) and 'soft' (rather suggestions than commands) institutions. Further, Edquist and Johnson acknowledge the three basic functions of institutions already established within the RIS approach (albeit formulated slightly differently), those being the reduction of uncertainty, management of conflict and cooperation, and provision of incentives.[80] Edquist and Johnson refer explicitly to 'institutions as patterns of behaviour' while discussing the three aforementioned functions. Nevertheless, it appears logical that these are applicable to 'institutions as concrete things' (organisations) as well. In fact, many (present-day) development agencies state such goals explicitly.

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[76] Martin and Sunley, "Conceptualizing Cluster Evolution."
[77] Charles Edquist and Björn Johnson, "Institutions and Organisations in Systems of Innovation," In *Systems of Innovation: Technologies, Institutions and Organisations*, ed. Charles Edquist, (London and New York: Routledge, 1997), 55.
[78] Peter G. Klein, "New Institutional Economics," (July 1998). Available at SSRN: https://ssrn.com/abstract=115811 or http://dx.doi.org/10.2139/ssrn.115811 ; Claude Ménard, "Methodological issues in new institutional economics," *Journal of Economic Methodology* 8, no. 1 (2005): 85-92.
[79] Edquist and Johnson, "Institutions and Organizations in Systems of Innovation," 47.
[80] Ibidem, 49-51.

A possible criticism of the application of the institutionalist approach in the context of industrial districts might be that the theories of industrial districts and institutions stem from different (and even opposing) schools of economics. Indeed, the new institutional economics developed in opposition to neoclassical economics, Alfred Marshall being a prominent representative of the latter. Yet, as it was already mentioned above, Marshall had dedicated much attention to the role of institutions in industrial districts as well as in the economy in general. After all, his (in)famous 'industrial atmosphere' is nothing but a fine (if somewhat too 'esoterically' formulated) example of an institution, whereby know-how is transmitted almost unconsciously within the district. Therefore, we may safely consider both approaches as complementary rather than exclusive.

Location theories

The theory of industrial districts, as developed by Alfred Marshall and others, can be seen as one of a broader range of location theories. In fact, it is classified as one of the neoclassical location theories. The neoclassical location theories use agglomeration economies as their central concept. Hence, they are most adequate for describing the further development of clusters once they are already in place (in order for agglomeration effects to take place, the firms already need to be present there in the first place), but less so when the initial location is concerned. As mentioned above, Marshall did acknowledge some factors of 'primitive localisation' in his works but did not elaborate them much further. The location of individual enterprises was a main topic of the classical location theories, which preceded the neoclassical theories. The oldest of classical location theories is the Land-use Theory by Heinrich von Thünen, first published in 1826. The most well-known of classical location theories is the Industrial Location Theory by Alfred Weber (published in 1909).[81] Weber's model defines the most advantageous location for a given industry as the one with the lowest transportation costs. In it, several factors are taken into account, such as the location of the main raw materials as well as the location of the markets where the final products are delivered. The classical representation, the so-called 'location triangle', takes the location of the two most important raw materials as two points, and the location of the market as the third. In some other interpretations, three points of the triangle represent the locations of raw materials, the labour pool and the markets. This theory, as well as others following the same (neoclassical) tradition, are very quantitative in their method. In order to apply them, exact data on transport costs and quantities of materials transported are needed. Therefore, unfortunately, it cannot be applied to the present case, as the quantitative data are largely lacking. Nevertheless, one important point should be remembered: industries that rely heavily on raw materials (including fuel) in large volumes, would naturally strongly gravitate towards the sources of these materials, such as coal and ore mines.[82] It seems reasonable to assume that the glass industry, which was quite notorious for its high fuel consumption, would follow this pattern. It should be noted, moreover, that the Weberian and Marshallian approaches are not mutually exclusive, as Weber devotes much attention to the agglomeration effects as well. Nevertheless, a principal difference remains. While the Weberian theory states that transport costs remain the most decisive factor, the Marshallian

[81] Michel van Dijk, "Locatietheorieën – Een historisch overzicht" (Unpublished Bachelor thesis, Erasmus Universiteit Rotterdam, Faculteit der Economische Wetenschappen, 2009), 1-30.

[82] Alfred Weber, *Theory of the Location of Industries* (Chicago: The University of Chicago Press, 1929) [originally published in German as *Über den Standort der Industrien* in 1909].

approach implies that after the establishment of the industrial district with its unique 'industrial atmosphere' (specialised labour markets, knowledge community, or the 'compound' localisation), the role of 'primitive localisation' may diminish. In other words, the formation of a Marshallian industrial district can become a self-reinforcing process.[83]

An interesting application of the location theories is to be found in the works of North American economic geographers on the location of industries in North-American (USA and Canada) cities during the 19th and 20th centuries. These works are interesting for several reasons. Firstly, they can be seen as an empirical application of the (mostly Weberian) location theories on the local level (that is, the level of city and agglomeration). This is also the level of analysis applied in the present study for the Charleroi region. Moreover, being empirical and historical in nature, they yield interesting observations, or even models that appear relevant for my case as well. For example, Allan Scott made a distinction between two types of industries in the 19th century. According to his model, within urban areas, *material-intensive industries*, such as those depending primarily on *weight-losing inputs*, especially fuels such as coal, which literally disappeared in the process, i.e. brick production and blast furnaces, tended to concentrate in close proximity to rail and water transport terminals. Meanwhile, *labour-intensive industries* tended to concentrate in central urban areas, in order to improve access for the workforce and to take advantage of the proximity of other firms, often thereby creating input-output linkages. It can be stated that the former types of industries followed a Weberian logic, while the latter type were more in line with a Marshallian logic. It could happen (and, indeed, it seems to have been the rule rather than the exception, at least in the North-American context), that in the 19th century both types of industrial activities tended to gravitate towards urban centres, but for different reasons. From the second half of the 19th century onwards, and especially from the early 20th century, industries tended to decentralise from the inner cities, in a process called 'industrial suburbanisation', due to the development of new transport modes (trucks) which made industries less dependent on railways nodes and created new arrangements of industrial facilities (single-floor factories) requiring more space. Again, these conclusions are mostly based on American examples.[84]

M. J. Webber (not to be confused with Alfred Weber) proposes an even more detailed classification of the 19th-century industries in this respect. The *first group* of industries is most strongly bound (even tied) to local materials and fuel. Examples include brickworks (clay) and breweries (water). These industries are located very close to or even on site with the source materials. The *second group* of industries uses large amounts of materials, but the weight loss during the production process is slight. They mostly use semi-finished products from other industries. Examples include shipbuilding and furniture making. These industries are located close to transport terminals for export to non-local markets (shipbuilding in or

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[83] Nicholas Alfred Phelps, "External economies, agglomeration and flexible accumulation," *Transactions of the Institute of British Geographers*, New Series 17, no. 1 (1992): 35-46.

[84] Raymond L Fales and Leon N. Moses, "Land-use theory and the spatial structure of the nineteenth-century city," *Papers of the Regional Science Association* 28 (1972): 49-80; Allen J. Scott, "Locational Patterns and Dynamics of Industrial Activity in the Modern Metropolis," *Urban Studies* 19, no. 2 (1982): 111-141; Robert D. Lewis, "The development of an early suburban industrial district: The Montreal ward of Saint-Ann, 1851-71," *Urban History Review/Revue d'histoire urbaine* 19, no. 3 (1991): 166-180; Gunter Gad, "Local Patterns of Manufacturing: Toronto in Early 1880s," *Urban History Review/Revue d'histoire urbaine* 22, no. 2 (1994): 113-138.

near ports) or at local markets in or close to the city core (furniture making). The *third group* of industries is characterised by large losses of weight when comparing the finished product with the raw materials (including fuel). Examples include the steel industry and heavy engineering. These industries tend to concentrate around transport nodes (rail and water). Lastly, the *fourth group* comprises labour-intensive small-scale industries with limited amounts of material per worker. Examples include clothing and jewellery. These industries tended to cluster together in order to achieve agglomeration economies and to concentrate in central urban areas to ensure labour access.[85]

The newest addition to the 'schools' of industrial locations is the New Economic Geography (hereafter NEG), first formulated by Paul Krugman in 1991. The basic concepts of the theory are *increasing returns and economies of scale*. This implies that the concentration of production is profitable. Moreover, labour and capital are regarded as mobile, while transport costs are taken into account as well. Somewhat paradoxically, this model implies that concertation tends to *increase* as transport costs *decrease*. When transport costs are high, enterprises tend to stay in their regions to serve local markets, as high transportation costs make long-range trade unprofitable. Further, in his explanation of the functioning of industrial concentration after their emergence, Krugman largely follows Marshallian principles, relying on three 'classical' Marshallian factors (externalities), i.e. specialised labour markets, technological spillovers, and the emergence of specialised suppliers (input-output linkages). Moreover, just like Marshall, Krugman attributes great importance to chance and even historical accidents for the initial location of the industry. Krugman's theory is in fact a two-region model (core-periphery), whereby the differences between the two are explained.[86]

Of the theories discussed, the Weberian location theory and its applications in the urban context seems most relevant for the present study, as both the scale (city/agglomeration) and period (19th century) are similar. The distinction of separating industries into four groups, as made by Webber, is particularly valuable, as it can provide a framework (or even a model) for the analysis of the location of window-glass factories within the region of Charleroi. Even without exact quantitative data, insights into the location of industries in relationship to the sources of materials and fuel used is worth considering. The comparative nature of the NEG is, however, beyond the scope of the present study.

'New Industrial Districts' and knowledge creation

The aforementioned book *The Competitive Advantage of Nations* (1990) by Michael E. Porter, as well as some of his other works, has caused a resurgence of interest in industrial clusters and districts in disciplines such as economic geography, urban studies as well as organisation and strategic studies. While the roots of these works still originate within Marshallian thinking, the industrial districts studied now are quite different from the classical Marshallian industrial districts of the 19th and early 20th centuries. Rather than being self-contained and based on manufacturing activities, these 'New Industrial Districts', as they are sometimes called, have porous boundaries, and are often defined by non-material economic activities.

[85] M. J. Webber, "Location of manufacturing activity in cities," *Urban Geography* 3, no. 3 (1982): 203-223.
[86] Robert Hassink and Huiwen Gong, "New Economic Geography" In *The Wiley Blackwell Encyclopedia of Urban and Regional Studies,* eds. Anthony M. Orum et al. (Chichester: John Wiley & Sons, 2019).

Examples include filmmaking (Hollywood), financial services (the City of London), IT (Silicon Valley) and even Formula One racing cars (British Motorsport Valley). As the development and management of knowledge is of special (even defining) importance for these 'New Industrial Districts', it is not surprising that many insights on this matter have been developed within this research tradition. These insights can be valuable for the study of 'old' industrial districts as well.[87]

In particular, the role of the interaction between local knowledge creation within the district (called 'buzz') and knowledge exchange between the district and the outside world (called 'pipelines') had been elaborated by Harald Bathelt et al. (2004). This view holds that both sources of knowledge are essential to assure a district's success.

The 'buzz' (also called 'noise' or 'local broadcasting' by other authors) refers to all the knowledge, often (but not exclusively) of a tacit nature, that is constantly created and updated within the district though formal and informal face-to-face interactions and other networking activities. It emerges more or less spontaneously. Those within the district participate in the 'buzz' without any specific investment. The 'buzz' contributes to the establishment of communities of practice. It can be assumed that the 'buzz' is more or less the same as the Marshallian 'industrial atmosphere', whereby 'the mysteries of the trade become no mysteries; but are as it were in the air'[88]. Hence, the 'buzz' is nothing really new. The concept of 'pipelines', on the other hand, does contribute something new. The 'pipelines' refer to interactions between both the district and outside actors, hence transcending local networks. While the 'buzz' is frequent, relatively unstructured and often spontaneous, the 'pipelines' work very differently. Establishing contacts with external, far-away partners is almost never automatic. It requires effort and time to build trust. Moreover, unlike 'buzz', 'pipelines' are not free, as investments are required.

While the role of 'buzz' ('industrial atmosphere') for the success of industrial districts has been acknowledged for a long time, the interest in 'pipelines' is much more recent. Bathelt et al. argue that both aspects are essential for the success of a district, as 'pipelines' allow for tapping into external knowledge sources, while the further dissemination of this knowledge within the district can occur through 'buzz'. Interestingly, they speak of the establishment of 'pipelines' by individual firms. It seems reasonable to assume that organisations can play an important role in this respect as well.[89]

An interesting addition to the industrial district theory, which has been developed since the 1990s, is the distinction between the horizontal and vertical dimensions of a cluster. The *horizontal dimension* comprises firms that produce similar products. In this case, firms act as competitors in the first place, while the input-output relationships and other inter-firm contacts are limited. The main advantage of geographical proximity in such a case is the possibility to keep a close eye on the characteristics of the products of competitors. This

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[87] Stephen Tallman et al., "Knowledge, clusters and competitive advantage," *Academy of Management Review* 28, no. 2 (2004): 258-271; Harald Bathelt, Anders Malmberg and Peter Maskell, "Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation," *Progress in Human Geography* 28, no. 1 (2004): 31-56.
[88] Marshall, *Principles of Economics*, 271.
[89] Bathelt, Malmberg and Maskell, "Clusters and knowledge," 36-45.

situation is conducive to rivalry and stimulates differentiation and variation between firms. *The vertical dimension* comprises firms that are complementary and interlinked via input-output relationships, acting as suppliers for each other, and developing close links, thereby lowering transaction and transportation costs. Marshall had already acknowledged this effect when he wrote about the rise of subsidiary trades within a district. However, more recent research has shown that input-output linkages are in fact limited even within traditional industrial districts.[90]

Industrial districts and historiography: Italy, Britain and beyond

From the early 1980s on, the 'slumbering' concept of Marshallian industrial districts reemerged and came to the fore when Italian economists such as Giacomo Becattini and Sebastiano Brusco directed their attention to the economic development of the central and northeastern parts of Italy, also known as the 'Third Italy'. This 'Third Italy' was defined in opposition to the industrial region of Northern Italy, which was dominated by large firms, and to the underdeveloped Southern Italy. The 'Third Italy' was characterised by a distinctive pattern of 'diffused industrialisation', whereby a large number of smaller firms formed complex systems of industrial organisation with many interdependencies, such as informal contracting and other systems of cooperation. This production system proved to be quite successful in the face of international competition, as it was remarkably adaptive and flexible, while assuring high wages. Hence, the contemporary economy of a 'Third Italy' could be described as a multitude of industrial districts, mostly specialised in light and labour-intensive production, such as for clothing, textiles, shoes, and furniture.[91]

By the mid-1990s historians started to show interest in industrial districts as well. While historical research on industrial districts was conducted in many countries, the United Kingdom proved to be especially receptive to the concept. In this research, the role of *institutions* came to the fore. While classical Marshallian theory mostly emphasised the role of more or less informal cooperation within districts, more recent research has shown that the role of various institutions and governance was of the utmost importance as well. These could include standard-setting bodies, vocational and education training systems, arrangements for the settlement of disputes and so forth. Or, as it was put by Sabel and Zeitlin: 'Industrial districts may develop a set of coordination and governance mechanisms capable of checking opportunistic behaviour without stifling fluid cooperation among decentralized economic actors. Crucial in this regard are resolution of disputes and the provision of collective services beyond the capacity of individual small and medium-sized firms to supply for themselves, such as training, research, market forecasting, credit, and quality control.'[92]

At the other end of the spectrum, the role of national institutions, governance mechanisms and public policies for the functioning of industrial districts have been acknowledged as well. Examples provided by Zeitlin include the structure of the financial and banking system and national policies towards cartelisation. Other examples that come to mind are the role of

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[90] Ibidem, 36-37.
[91] Zeitlin, "Industrial districts and regional clusters," 219-220.
[92] Ibidem, 226.

central states in the promotion of international trade for export-oriented industries, or the national invention patent legislation.[93]

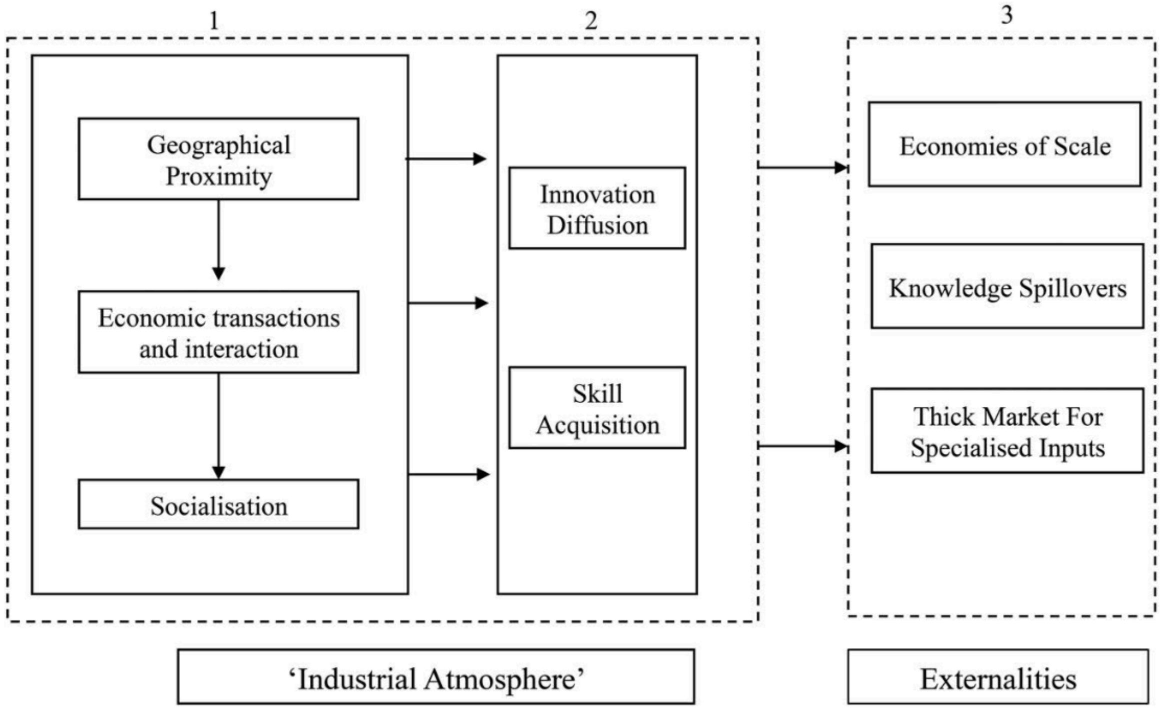
One theoretical concept that became closely associated with industrial districts is the idea of *flexible specialisation*, also known as the *historical-alternatives approach*. The basic idea of this approach originated in the 1980s. Already in 1984, the alternatives to mass production by means of flexible specialisation were discussed by Michael J. Piore and Charles F. Sabel. In 1989, Pat Hudson edited a collection of essays under the title *Regions and Industries*. Here, the diversity of experience of various regions during the Industrial Revolution was emphasised, while the notion of a 'standard' development path was questioned.[94]

In their article on flexible specialisation (1985), Charles Sabel and Jonathan Zeitlin explicitly refer to Marshallian industrial districts as environments where this kind of industrial organisation was most likely to thrive. Many small and medium-sized firms, operating in close proximity within a district, could swiftly adapt their production assortment in response to changing tastes, as well as open new markets by adapting to various demands. This flexibility was favoured by mutual subcontracting, which was widespread within districts. This organisation could be opposed to the production by large factories that, due to their large size, could rely on internal economies of scale, thus being less dependent on cooperation with other firms. Yet such large factories were less flexible, making them less adaptable to changing circumstances, such as new fashions. Hence, the small-scale firms operating within industrial districts were not inferior or obsolete in comparison to large factories, but they were an *alternative form* of industrial organisation.[95]

A new summary of the theory of industrial districts was formulated by Chris Corker, Joe Lane and John F. Wilson in 2022. This summary, called 'The Marshallian Industrial District Paradigm' is represented in the Figure 1:

[93] Ibidem, 225-227.
[94] Lane, "Networks, Innovation and Knowledge," 28-39.
[95] Sabel and Zeitlin, "Historical Alternatives to Mass Production," 133-176.

Figure 1: The Marshallian Industrial District Paradigm



Source: Corker, Lane and Wilson, "Critical perspectives on industrial clusters," 263

The 'Industrial atmosphere', that is, the unceasing circulation of knowledge, corresponds with the boxes 1 and 2 from the figure, while the box 3 represents the immediate positive externalities that are engendered by this flow of knowledge. Due to the geographical proximity, the exchange of information and socialisation are promoted (box 1). This leads to the facilitation of the diffusion of innovations between firms and acquisition of skills by workers (box 2). Finally, positive externalities (box 3) result from both the 'Industrial atmosphere' and the agglomeration economies, such as the concentration of physical and human capital. For instance, the emergence of 'thick markets' for the specialised labour (skills) can be seen as an example of the latter.[96]

Industrial districts: concluding remarks

As appears from the overview provided, the theory of industrial districts has gone a long way within economics in the more than one hundred years since it was first formulated by Marshall. The last issue to address is its relevance for historical research on 19th century industrialisation. There should be little doubt on this matter, however. The theory itself was very empirical originally, as Marshall based it on his observations of the 19th-century British industry. Later evolution of the theory in the 20th century, such as the 'new industrial districts' approach, naturally shifted attention to the 20th century developments. Yet the 'rediscovery' of the theory by historians in the 1980s and onwards clearly indicates the relevance of the theory for historical research as well, including research on the 19th

[96] Chris Corker, Joe Lane and John F. Wilson, "Critical perspectives on industrial clusters," in *Industrial clusters: knowledge, innovation systems and sustainability in the UK*, eds. John F. Wilson, Chris Corker and Joe Lane (London and New York: Routledge, 2022), 263-264.

century. Two edited volumes, one published in 2003, another in 2022, attest to the development of historical research on industrial districts in the United Kingdom. The range of examples includes North Staffordshire Potteries, armaments industries in Sheffield and electronics in North East England, attesting to the broad scope of this approach.[97] The historical research within this tradition takes place in other parts of the world as well. Some relatively recent examples include the silk-weaving district of Kiryu, Japan during the Meiji era and furniture and maritime clusters in the Møre og Romsdal county in Norway between 1900 and 2010.[98] Hence, at the present moment, this approach can be described as firmly established and fruitful in the global context of economic and business history.

To summarise, the basic Marshallian premise is still relevant after more than one hundred years, as attested by recent international historiography. At the same time, it can be enriched by concepts developed later, both within and outside the 'Marshallian tradition'. These include:

- *Location factors* of industries. The aforementioned works of Webber and others on the location of industries within the 19th-century Northern American urban agglomerations appear most relevant for the present study, as already discussed.
- *Agglomeration economies* that go beyond 'classical' Marshallian externalities.
- The impact of *institutions* and *organisations* for the functioning of industrial districts, at both the local and the international level.
- Mechanisms and arrangements for the creation and management of *knowledge*.
- Systems of *industrial organisation*, such as flexible specialisation.

Some of these concepts, such as various knowledge-management strategies, will be discussed in more detail further.

The last issue to address is the relationship between the causes and consequences of industrial clustering and how the theories discussed can address this. In other words, which theories are better at explaining causes, and which at explaining consequences? In my opinion, the Weberian model of industrial location is better at explaining the *initial factors of location* of industries, whereas the Marshallian model is more adequate for the explanation of the *further development* of industrial districts, whereby agglomeration effects grow in importance with time. Hence, again, both models are to be regarded as complementary rather than exclusive. Yet, as already mentioned, the initial clustering tends to become self-reinforcing, hence blurring the distinction between cause and consequence.

Two analytical models of industrial districts

[97] Wilson and Popp, *Industrial Clusters and Regional Business Network*; Wilson, Corker and Lane, *Industrial clusters: knowledge, innovation systems and sustainability.*

[98] Tomoko Hashino and Takafumi Kurosawa, "Beyond Marshallian Agglomeration Economies: The Roles of Trade Associations in the Meiji Japan," *Business History Review* 87, no. 3 (Autumn 2013): 489-513; Rolv Petter Amdam and Ove Bjarnar, "Globalization and the Development of Industrial Clusters: Comparing Two Norwegian Clusters, 1900-2010," *Business History Review* 89, no.4 (Winter 2015): 693-716.

After the description of the development of the concept of industrial districts over more than one hundred years, the following paragraphs will present two models that will serve as an analytical tool for the study of the evolution of districts. Indeed, the paths that various districts have followed differ widely. While some experienced the 'decline and fall' after their initial rise, others could adapt themselves to the changing circumstances. This dynamic is often understood in terms of life cycles. The 'classical' life-cycle model of industrial district by Peter Swann distinguished four distinct stages: critical mass, take-off, saturation and maturity.[99]

Moreover, the structures that emerged within districts, such as the level of centralisation of firms, varied vastly as well, and they were far from static either. Hence, reviewing the process of change (and the various paths it could take) is essential for the better understanding of industrial districts.

The two models presented will allow us to better understand and explain the dynamic evolution of the glass-making district of Charleroi in particular during the period under consideration, and will help to answer the research questions postulated (see general introduction). Indeed, the district of Charleroi experienced profound change, especially with respect to the provision of raw materials, the financial resources needed, and the organisations that emerged.

This first model (hereafter referred to as the 'four-quadrant model') was developed by Andrew Popp, Steve Toms and John Wilson (2006) within the context of the historical study of industrial districts in the United Kingdom. It represents various types of industrial organisation that were possible within an industrial district, depending on various factors. It is well suited for dynamic analysis, as it can explain the shift from one type of organisation to another as caused by changing circumstances, such as technological innovations.[100]

The second model, the 'Modified Adaptive System' model by Martin and Sunley (2011), allows a better understanding of the historical evolution (life cycle) of an entire district. However, unlike most life-cycle models, including that of Peter Swann, it does not prescribe one standard path of development. Rather, it allows for various trajectories depending on various circumstances (hence 'adaptive' in its name).[101] As noted by Corker, Lane and Wilson, this model can be applied within the industrial district approach.[102]

However both models focus on the dynamic characters and change of industrial districts, but in different ways. The 'Modified Adaptive System' model explains the *evolution of industrial districts as a whole* in the long run, whereby the entire district passes through a series of stages, such as emergence, growth, maturation and others. The 'four-quadrant model', on the other hand, explains how the *internal structure of an industrial district* can change and adapt. Both processes (the passage through the stages of the life cycle and the shifts of

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[99] Peter Swann, "Towards a Model of Clustering in High-technology Industries", In *The Dynamics of Industrial Clustering: International Comparisons in Computing and Biotechnology*, ed. Peter Swann, Martha Prevezer and David Stout (Oxford: Oxford University Press, 1998), 52-76.
[100] Popp, Toms and Wilson, "Industrial districts as organizational environments."
[101] Martin and Sunley, "Conceptualizing Cluster Evolution."
[102] Corker, Lane and Wilson, "Critical perspectives on industrial clusters," 262-263.

internal structure) can occur simultaneously. For instance, a district can experience maturation due to the saturation of the market for the good produced, while experiencing change in the internal structure due to the change of availability of the necessary resources.

The model of industrial districts as organisational environments

The 'four-quadrant model' is based on a combination of the 'resource-based view' (RBV) of the firm and the 'resource-dependency' (RD) theory.

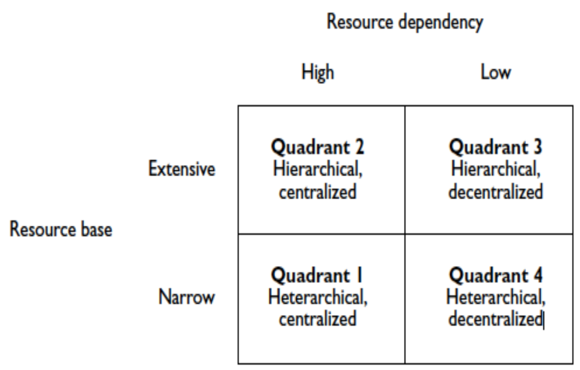
The RBV looks at the competitive advantage of firms as based on the possession of unique or difficult-to-replicate assets, such as raw materials and labour. Here, the 'narrow' resource basis stands for specialised resources, and 'extensive' is for the opposite situation. According to the RBV, the behaviour of a firm can be explained by the resource base ('narrow' or 'extensive') that it requires. Within the context of industrial district, the resource base is often the consequence of the development of a district itself.[103]

Within the RD theory, the resource dependency stands for (external) capital. The dependency on capital is important for the determination of the level of external control of the industrial production within the district. If the dependency is high (there is much capital required), the district becomes dependent on the availability of external sources, such as banks and other financial institutions.[104]

It should be noted that, unfortunately, the RBV and RD both use the term 'resource' but with a different meaning, hence special attention is required here in order to avoid confusion.

Taking the 'resource base' and 'resource dependency' as two axes, the model can be represented graphically (Figure 2) with four quadrants, providing four possible types of organisation:

Figure 2: Four-quadrant model of industrial districts



Source: Popp, Toms and Wilson, "Industrial districts as organizational environments," 360

Figure 2 shows that the structure and governance of the district depend on the combination of resource bases and resource dependencies. The difference between extensive and narrow

[103] Popp, Toms and Wilson, "Industrial districts as organizational environments," 355-356.
[104] Ibidem, 356.

resource bases influences directly the degree of specialisation between firms. In the case of resource bases of various firms being 'narrow', different firms then tend to specialise their economic activities within the value chain. This situation is designated as 'heterarchical' in the figure (quadrants 1 and 4). In this case, the main function of governance (organisations and institutions) would be to assure vertical coordination between firms. The Birmingham Jewellery Quarter presents an example of such a situation. There was a high degree of diversity between firms in terms of their production, yet much less diversity in firm size.[105]

In the case of an extensive resource base between firms (quadrants 2 and 3), the district structure tends to become horizontally fragmented. This means that the specialisation between firms is limited, with most firms being similar. In this case, the governance mainly functions to control or even limit competition between firms. The sharing of information can be promoted by the governance as well. The Staffordshire Potteries provide an example of such a situation. There was little diversity between firms in terms of size of production.[106]

Now, within the *narrow resource base*, two situations are possible. When the reliance on external resources (finance) is low (Quadrant 4), a relative equality between firms is often promoted by arrangements to share resources. In order to avoid free-riding, price fixing and other norms can be imposed through industry associations. Information sharing and other forms of cooperation, such as training and marketing, are likely to occur. However, despite high levels of coordination, such industrial districts tend to remain decentralised.[107]

When reliance on the external resource (finance) becomes increases while retaining narrow individual resource bases (Quadrant 1), centralisation is likely to occur, as small firms are unable to secure all the financial resources needed.[108]

Within the *extensive resource base*, again two situations are possible. When the reliance on external resources is low (Quadrant 3), firms tend to be generic in their activities, and show little diversity. Industrial districts with such a structure are less inclined to develop classical positive forces that are associated with industrial districts. Yet some kinds of arrangements can occur in order to control competition within the district.[109]

When the reliance on external resources (finance) increases while retaining extensive individual resource bases (Quadrant 2), long-distance connections can become more important than clustering forces within a district. The firms still tend to be generic in their activities and show little diversity. Just as in the previous case, the role of governance is mostly to control the competition. At the same time, the role of external providers of financial resources becomes more prominent.[110]

The four-quadrant model is not static. The transitions of entire districts across the matrix (from one quadrant to another) can be caused by changes of technology, markets and other

[105] Ibidem, 360-361.
[106] Ibidem, 362.
[107] Ibidem, 361.
[108] Ibidem, 361.
[109] Ibidem, 362.
[110] Ibidem, 362.

factors. However, rigid governance arrangements can hinder transitions. The successful transitions can be hindered by the so-called 'lock-in', whereby rigid forces hinder successful restructuring. Three principal types of lock-in are distinguished, namely cognitive, political and functional.[111]

The Modified Adaptive System model

The process of long-term change in industrial districts has often been described in terms of life cycles. However, not all districts follow the same path. While some follow the classical trajectory of emergence–critical mass–take-off–growth–maturation–exhaustion (such as proposed by Peter Swann, for instance[112]), others are able to revive themselves and enter a phase of renaissance. Hence, the process as suggested by 'classical' life cycles theories is not inevitable.[113] The classical life-cycle models are inspired by biological analogies, whereby the 'life' of a product or technology is compared with the life of a biological organism. This implies a linear and deterministic development. Such models were first developed in relation to specific products and technologies. Later, lifecycle thinking was applied to industrial districts and clusters. Here, two approaches emerged, the *industrial-technological cycle* and the *cluster-specific cycle*.

The former approach simply implies that the cluster follows the same cycle as the industry in which it is specialised. Specifically, five main stages are distinguished: emergence (or birth)–growth–maturity–decline (even death). Moreover, most followers of this approach agree that cluster effects are most valuable in the early stages when the product is still in the development stage and innovation activities are being deployed. After the 'maturation' of the industry, when the product design becomes established, cluster effects become less important.[114]

The latter approach explains the evolution of industrial districts and clusters out of the cluster-specific processes themselves, that is, through the balance between agglomeration advantages and disadvantages. According to this view, too much clustering causes agglomeration disadvantages to outweigh agglomeration advantages, thus leading the whole district into decline.[115]

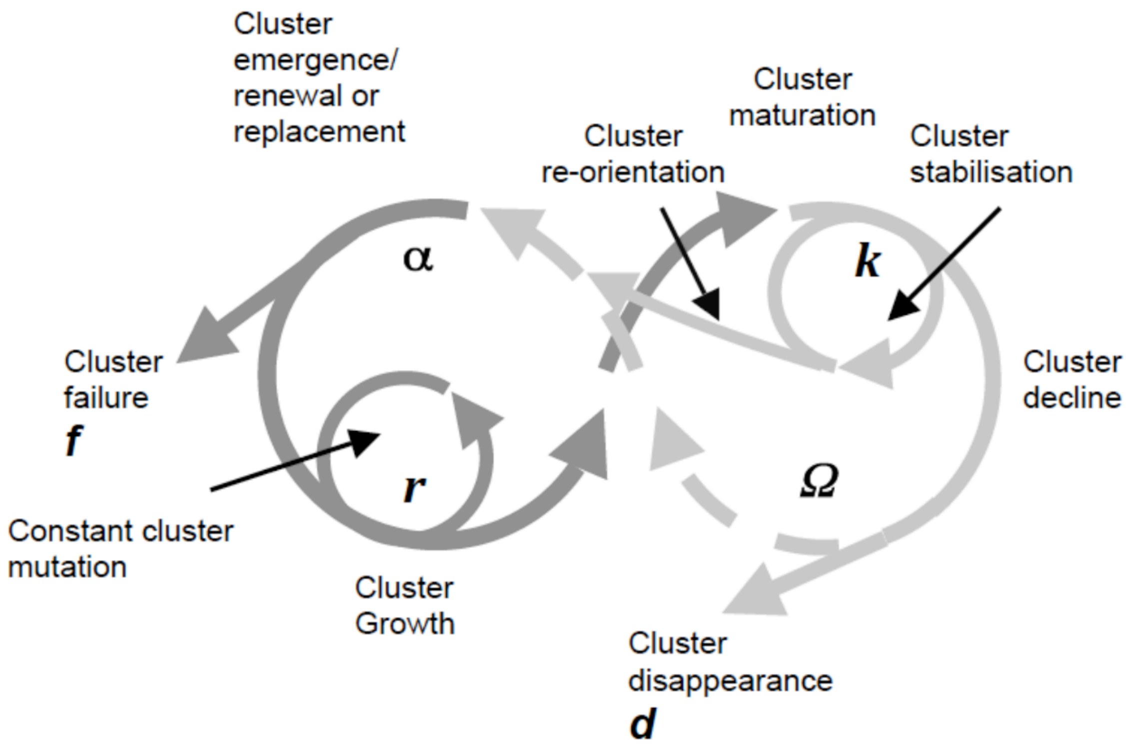
However, it is questionable whether the underlying analogy with a living *organism* is an applicable one. As argued by Ron Martin and Peter Sunley, an ecological analogy with a *population* of entities would be a much better fit. Just as an ecosystem or a habitat is composed of a multitude of organisms, an industrial district is 'inhabited' by a multitude of firms. This is the basic idea of their 'Modified Adaptive System' model which is, as the name already suggestsnot deterministic. Instead of one 'classical' trajectory, it proposes six basic possible trajectories, directing attention to the permanently ongoing process of adaptation. The path of evolution is a result of decisions made by firms within the district. In this respect, agency matters. Innovation especially can help a district to realise a new revival instead of

[111] Ibidem, 364.
[112] Swann, "Towards a Model of Clustering," 52-76.
[113] Charles, "The evolution of business networks and clusters," 32-55.
[114] Martin and Sunley, "Conceptualizing Cluster Evolution," 1301-1303.
[115] Ibidem, 1302.

decline. Industrial districts can 'reinvent' themselves and show a high degree of resilience by innovating. However, a district can develop 'lock-in' due to rigidities, ultimately failing to innovate and subsequently going into decline.

The possible trajectories are represented by the Figure 3 and a the Table 4 from an article by Martin and Sunley.[116]

Figure 3: Alternative cluster evolutionary trajectories according to the Modified cluster adaptive cycle model



Source: Martin and Sunley, "Conceptualising Cluster Evolution," 1312

Table 1: Alternative cluster evolutionary trajectories according to the Modified cluster adaptive cycle model

Evolutionary trajectory	Phases of evolution and typical characteristics	Possible mechanisms
1. Cluster full adaptive cycle	Emergence, growth, maturation, decline and eventual replacement by a new cluster. Follows the archetypal adaptive cycle. The replacement cluster is likely to draw upon resources and capabilities	Resilience rises and then falls as the cluster passes through phases of the cycle. The cluster atrophies because of either internal rigidities or exhaustion of increasing returns effects, or it is unable to withstand major external competitive

[116] Ibidem, 1312-1313.

	inherited from the old cluster	shock. But sufficient resources, inherited capabilities and competencies are left to provide a basis for the emergence of a new cluster based on related or cognate specialism
2. Constant cluster mutation	Emergence, growth, and constant structural and technological change. The cluster continually adapts and evolves, possibly by the successive development of new branches of related activity. This is particularly likely where basic technology has generic or general-purpose characteristics	Cluster firms are able to innovate more or less continuously and the cluster constantly mutates or widens in terms of industrial specialisation and technological regime. There are high rates of spin-offs from existing firms and spin-offs from local research institutes or universities. Cluster has a high degree of resilience
3. Cluster stabilisation	Emergence, growth and maturation, followed by stabilisation, though possibly in a much reduced and restricted form. The cluster might remain in this state for an extended period of time	Though the cluster possibly experiences a phase of decline in scale, the remaining firms survive by upgrading products and/or focusing on niche or prestige market segments. The cluster retains a modest degree of resilience, but it remains potentially vulnerable to (further) decline
4. Cluster reorientation	Upon reaching or nearing maturation, or upon the onset of early cluster decline, firms reorient their industrial and technological specialisms, and a new cluster emerges	The cluster in effect branches into a new form without going through a long period of decline. The more innovative lead firms may play a key role in this process, for example by reacting to market saturation or a rise of major competitors, or a technological breakthrough may activate reorientation
5. Cluster failure	The emergent cluster fails to take off and grow. Any	The cluster fails to achieve sufficient critical mass,

	remaining firms do not constitute a functioning cluster	externalities or market share. Innovation may also falter. New firm formation is low and/or the firm failure rate is high, which deters new entrants
6. Cluster disappearance	Emergence, growth, maturation, decline and elimination. No conversion into or replacement by a new cluster. Classic life cycle trajectory	The cluster experiences the same eventual atrophy and decline as in the full adaptive cycle pattern (see point 1 above), but inherited resources and competences are not sufficient or ill-suited to form the basis of new cluster formation

Source: Martin and Sunley, "Conceptualizing Cluster Evolution," 1312

Chapter 1.2: Outline of the economic history of Belgium in the 19th century

The present chapter provides a general overview of the economic development of present-day Belgium from the late 18th century up to 1914. It is intended as context within which the development of the window-glass industry should be positioned and does not contain any original research. A note on geographical delimitations is necessary, however. In the context of the Early Modern period (up to around 1800), present-day Belgium is designated as the Southern Low Countries (as opposed to the Northern Low Countries, which is present-day Netherlands) in historical writing. More specifically, between 1713 and 1784 this region was known as the Austrian Netherlands, as it was ruled by Austrian Habsburgs. It should be kept in mind that the Austrian Netherlands did not coincide with present-day Belgium completely, as they included some territories that are not part of Belgium (present-day Grand Duchy of Luxembourg) while the Prince-Bishopric of Liège was not a part of the Austrian Netherlands.

The designations of Flanders and Wallonia are problematic as well. The 'modern' concepts of Flanders and Wallonia (that is, the Dutch- and French-speaking parts of Belgium, encompassing five provinces each) only emerged in the course of the 19th and early 20th centuries.

The onset of industrialisation

Belgium is generally known as the first country on the European continent to experience the Industrial Revolution from the early 19th century onwards. This development did not appear out of nowhere, as the Southern Low Countries had already hosted a well-developed economy in the 18th century. Within the Flemish countryside (the present-day provinces of East and West Flanders mostly), the cottage linen industry developed along the lines of proto-industrialisation. At the same time, within the present-day Walloon provinces of Hainaut and Liège, various metalworking industries gained importance. Here, as well, large parts of production were organised as a cottage industry. The Liège region was renowned for the armaments industry as well as for the production of nails. The cottage nail production, organised along the lines of proto-industrialisation, was also typical for the rural areas around Charleroi. Moreover, coal mining was practised in these regions from mediaeval times onwards.[117]

The occupation of the Southern Netherlands by the French in 1784 and the effective annexation to France in the following year signified a real milestone for the economic development of present-day Belgium, as the vast French market became accessible, while old organisation networks, such as craft guilds, were abolished. The final defeat of France in 1815 (Waterloo) and the subsequent integration of present-day Belgium into the newly established United Kingdom of the Netherlands in 1815 did cause some perturbations, but not a lasting crisis. The same can be said of the Belgian revolution and independence in 1830. Certainly, the loss of the French market in 1815 and of the Dutch colonial market in 1830 caused difficulties, but these were overcome rather quickly. Hence, despite the political turmoil, the industrial development proceeded in a rather continuous fashion from 1795 on. It should be noted that the brief period of the United Kingdom of the Netherlands (1815-1830) was of great importance, as King William developed a conscious economic policy, providing industrial enterprises with favourable loans and supporting industry in other ways, for instance by attracting skilled workers from other countries.[118]

Regions and sectors of Belgian industrialisation

The economic development of Belgium was very much region-based, as various growth poles can be distinguished, such as Ghent, Verviers, Liège, Charleroi, Centre (La Louvière) and Borinage (Mons). Moreover, each of these industrialising regions developed its own profile of industrial activities. Except for Ghent, all these growth poles were situated in Wallonia.[119]

To begin with, Ghent (the present province of East Flanders) became a major centre of the cotton industry from the first years of the 19th century onwards.[120] Other industries, such as mechanical engineering, emerged in Ghent as well. For instance, the Ghent firms Van de Kerckhove, Le Phenix and Carels were known for the production of steam engines and other pieces of machinery.[121] At the same time, Verviers (the province of Liège) became another

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[117] Herman Van der Wee, "The Industrial Revolution in Belgium," in *The Industrial Revolution in national context. Europe and the USA*, eds. Mikulas Teich and Roy Porter (Cambridge: Cambridge University Press, 1996), 64-67; Marinette Bruwier, "De nijverheid voor de industriële revolutie: een proto-industrialisatie?" in *De industrie in België. Twee eeuwen ontwikkeling 1780-1980* (Brussels: Gemeentekrediet van België, 1981), 13-24.
[118] Van der Wee, "The Industrial Revolution in Belgium," 64-77; K. Veraghtert, "Ambacht en nijverheid in de Zuidelijke Nederlanden 1790-1844," In Vol. 10 of *Algemene geschiedenis der Nederlanden*, ed. Dick Peter Blok (Haarlem: Fibula-Van Dishoeck, 1977-1983), 254-256; Bruwier, "De nijverheid voor de industriële revolutie," 13-24; Pierre Lebrun, "De industriële revolutie," In: *De industrie in België. Twee eeuwen ontwikkeling 1780-1980* (Brussels: Gemeentekrediet van België, 1981), 25-48.
[119] Van der Wee, "The Industrial Revolution in Belgium," 64-77; Lebrun, "De industriële revolutie," 45-47.
[120] K. Veraghtert, "Ambacht en nijverheid," 256-262.
[121] Guido Deseyn, "Flanders Technology in Rusland. De uitvoer van Stoommachines Van De Kerkchove naar Rusland tussen 1880 en WOI," *Tijdschrift voor industriële cultuur* 12, part 45, no. 1 (January-February-March 1994), 96-101.

major textile centre, developing a mechanised wool industry from the late 18th century onwards.[122]

The Liège region was mainly characterised by coal mining, metallurgy and mechanical engineering, understood as the production of machinery and industrial equipment of various kinds. This development is exemplified by the firm of the English immigrant mechanic William Cockerill and his son John, and was first established in Verviers in 1799 and then moved to Liège in 1807. During the following decades, William and John developed their company further into a vertically integrated business empire, encompassing all steps of metallurgical and engineering production from coal mining and iron smelting to the production of final products, such as steam engines, railway locomotives and many other types of production. In the wake of the Cockerills, many other enterprises were established in Liège and its surroundings, mainly within the fields of coal mining, metallurgy and mechanical engineering.[123]

More to the west, the region of Charleroi (the province of Hainaut) started to industrialise as well. The coal mining, metallurgy and glass industry had been established here as early as the 17th and 18th centuries. New technologies, such as coke-fired blast furnaces, were introduced from the 1820s onwards. The region of Charleroi was the centre of the Belgian window-glass industry, and therefore forms the casus of the present study. If we are to look at the relative position of the Charleroi region within industrialising Belgium, it can be stated that it possessed less of an industrial tradition than Liège. While Liège excelled in fine metalwork from the late Middle Ages on already, Charleroi was specialised in rather 'crude' metalwork, such as the production of nails, on the eve of the Industrial Revolution. However, in the course of the 19th century, Charleroi developed a more diversified industry, while still retaining coal mining, metallurgy and glass production as basic industries.[124]

Another industrial region developed in the area known as Borinage or Couchant de Mons around the city of Mons (the province of Hainaut). It had been known for its large-scale coal mining from the 18th century onwards. However, the development of other industries remained limited in this region.[125]

From the 1830s onwards, a new industrial region started to emerge between Borinage (Mons) and Charleroi around the present-day town of La Louvière, known as the Centre, and coal mining started to develop here.[126] With time, other industries started to develop in this region, such as stone quarries, a glass industry, ceramics and mechanical engineering.[127]

As the regions of Charleroi and Centre housed the lion's share of the Belgian window-glass industry, they form the main focus of the present study. Therefore, their industrial development will be discussed in more detail in a separate chapter.

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[122] K. Veraghtert, "Ambacht en nijverheid," 256-262.
[123] Ibidem, 262-264.
[124] Erik Buyst, "The Causes of Growth during Belgium's Industrial Revolution." *Journal of Interdisciplinary History* XLIX, no. 1 (Summer 2018): 71-92; Veraghtert, "Ambacht en nijverheid," 264-265.
[125] Veraghtert, "Ambacht en nijverheid," 264-265.
[126] Ibidem, 264-265.
[127] Isabelle Sirjacobs, *Le Centre, une région façonnée par l'industrie*. Carnets du Patrimoine 82. (Namur: Institut du Patrimoine wallon, 2011), 7-10.

The present outline does not imply that industrial development did not occur outside the aforementioned growth poles of Ghent, Verviers, Liège, Charleroi, Centre and Mons (Borinage). For example, a relatively small yet vibrant center of mechanical engineering emerged in the smaller city of Mechelen in Flanders (the present province of Antwerp in Flanders) around the main workshops of the Belgian State Railways, known as the Arsenal (het Arsenaal), founded in 1836. While the Arsenal had employed 700 workers in 1855, the number had risen up to three thousand by 1890.[128] Nevertheless, broadly speaking, the geographical distribution of the Belgian industries remained as described above during the entire period up to the First World War. It is very obvious that the centre of gravity was situated in the southern (Walloon) provinces of Hainaut and Liège. While Ghent remained an isolated industrial 'enclave' within the largely unindustrialised Flanders, the Walloon region(s) of Verviers–Liège–Charleroi–Centre–Mons developed into a true industrial axis, stretching in an east-west direction.[129] New industrial regions started to develop in Flanders only after the First World War, as for example along the Brussels–Willebroek–Antwerp waterway (canal and the river Scheldt) that acted as an axis too. It can be noted that some 'pioneer enterprises' already emerged there in the late 19th century, especially in the industrial town of Willebroek.[130]

This region-based development calls for an explanation. While the spatial structure of Belgian industry on the national scale has already been studied by Paul Olyslager (1947),[131] more recent studies include articles by geographers Christian Vandermotten (1998)[132] and, more recently, by Michiel van Meeteren, Kobe Boussauw, Ben Derudder and Frank Witlox (2016).[133] According to Vandermotten and van Meeteren et al., the spatial structure of Belgian industrialisation went through different stages of economic development. During the pre- and proto-industrial stages (from the Middle Ages up to the early 19th century), the main nodal points were located along the two main waterways, the rivers Scheldt and Meuse, and their tributaries. During the early stages of industrialisation (the late 18th – early 19th centuries), the development of industries was still largely bound to the place where natural resources were located. More specifically, the coal deposits were responsible for the emergence and development of the Walloon industrial axis (Verviers–Liège–Charleroi–Mons, also known as the 'sillon industriel'), which encompassed all the initial centres of Belgian industrialisation with the exception of Ghent.[134]

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[128] Paul Van Heesvelde, "Living apart together? La ville de Malines et l'Arsenal – Atelier central des Chemins de fer de l'État (1836-1914)," *Revue d'histoire des chemins de fer*, no. 28-29 (spring-autumn 2003): 424.
[129] Christian Vandermotten, "Dynamiques spatiales de l'industrialisation et devenir de la Belgique," *Le Mouvement social*, no. 85 Industrialisations Européennes (October-December 1998): 75-100.
[130] Sofie De Caigny, "New Economic Geography als bedrijfshistorische invalshoek: de transformatie van de kanaalzone ten noorden van Brussel tot een industriegebied in het interbellum," *Belgisch Tijdschrift voor Nieuwste Geschiedenis* 33, no. 3-4 (2003): 535-575.
[131] Paul Olyslager, *De localisering van de Belgische nijverheid* (Antwerp: Standaard, 1947).
[132] Vandermotten, "Dynamiques spatiales de l'industrialisation."
[133] Michel van Meeteren et al., "Flemish Diamond or ABC-Axis? The spatial structure of the Belgian metropolitan area," *European Planning Studies* (2016): 1-22.
[134] Vandermotten, "Dynamiques spatiales de l'industrialisation," 80-82; Michel van Meeteren et al., "Flemish Diamond or ABC-Axis? " 4-6.

From approximately the 1880s and 1890s onwards, a new industrial axis started to develop. This new axis, known as the ABC-Axis (Antwerp–Brussels–Charleroi), stood geographically perpendicular to the old Walloon axis. The development of the ABC-Axis can be explained by various factors, such as the emergence of new industries (for instance, the chemical industry) and the further development of transport infrastructure. Belgian investments and other economic activities overseas reinforced the role of the port of Antwerp, which attracted many new industries. Yet, the development of the ABC-Axis largely occurred after the First World War, and is therefore beyond the scope of this present study.[135]

From a more theoretical perspective, the development of the Walloon axis can be explained by the location theory of Alfred Weber. As discussed above, this neoclassical location theory is based on the role of transport costs, whereby the location of the main raw materials as well as the location of markets where the final products are delivered are taken into account. In the early 19th century, when the Walloon axis took shape, the location of coal was largely defining for the location of industries, especially the energy-intensive ones, such as metallurgy and glass production.

Later developments of the ABC-Axis are possibly better understood within the framework of the New Economic Geography that puts more emphasis on the development of new transport infrastructure as, for instance, discussed by Sofie de Caigny in her article on the role of the Brussels–Antwerp waterway (2003). However, as these developments largely occurred after the First World War, they will not be further discussed here.[136] The location factors that acted on a lower (regional and local) scale for window glass specifically, will be discussed further.

Service economy: transport and finance

Alongside the industrial growth poles, two predominantly service-oriented growth poles, Antwerp and Brussels, should be mentioned. Antwerp was the main port of Belgium. Its port infrastructure as well as the hinterland transport connections by canals and railways were expanded throughout the 19th century.[137] Manufacturing industry developed in Antwerp alongside commercial activities, especially after 1850. Shipbuilding was the most prominent sector, as represented by Cockerill Yards, subsidiary of the aforementioned Liège enterprise. Shortly before 1900, the new automobile industry was established in Antwerp. In 1906, the Antwerp factory Minerva was the largest Belgian automobile manufacturer, employing 1600 workers.[138]

Brussels, being the national capital, housed political, administrative and, most importantly, financial and banking institutions that were essential for the economic development of the entire country.[139] It should be noted that, while being a financial and banking centre

[135] Vandermotten, "Dynamiques spatiales de l'industrialisation," 82-87; Michel van Meeteren et al., "Flemish Diamond or ABC-Axis? " 6-8.
[136] De Caigny, "New Economic Geography als bedrijfshistorische invalshoek," 535-575.
[137] Van der Wee, "The Industrial Revolution in Belgium," 64-77.
[138] Luc Peiren, *IJzersterk. De geschiedenis van de Vlaamse metaalindustrie* (Ghent: Amsab-Instituut voor sociale geschiedenis vzw, 2018), 36-41.
[139] Van der Wee, "The Industrial Revolution in Belgium," 64-77.

primarily, the national capital possessed a vibrant industrial sector as well, with industries such as chemicals, textiles, metalworking and mechanical engineering alongside others, many of them situated along the Brussels-Willebroek-Antwerp waterway.[140]

The industrial development would have been impossible without the development of infrastructure of various kinds. The transport network was already well developed in the 18th century. At that time, new canals were dug and existing rivers improved, while the total length of paved roads (*chaussées*) within the Southern Netherlands increased from 229.6 km in 1704 to 2,841 km in 1793 (including 358 in the then Prince-Bishopric of Liège), creating one of the most dense and well-developed transport networks in the world.[141] The improvement and expansion of the waterway and road network proceeded in the 19th century, but the true transport revolution occurred with the introduction of railways. Starting with the first line, inaugurated between Brussels and Mechelen in 1835, a total network of 4,691 km was built by 1913.[142]

As for the region of Charleroi and the window-glass industry specifically, its transport network remained relatively poorly developed until the first railway connection with Brussels in 1843. As will be discussed further in Part 1, Chapter 1.3, water transport remained rather deficient until the early decades of the 20th century, as the main connection with Brussels existed in the form of a paved road, *Chaussée de Bruxelles*, built in the early 18th century.[143]

The banking and finance infrastructure was no less important. In Belgium, mixed banks, which combined commercial banking with long-term investments, played a particularly important, even dominant role in the process of industrialisation. As these banks provided the capital needed, they gained control over the industry in return. Quite literally, credits provided by banks to enterprises were transformed into shares, effectively turning banks into bodies that controlled large parts of the industry. Two dominant (and competing) banks were the *Société Générale de Belgique*, founded in 1822, and *Banque de Belgique*, founded in 1835. Both banks experienced a serious crisis in 1838-1839 due to the 'investment fever' (careless investments) and general economic slowdown. Afterwards, the *Banque de Belgique* refrained from further investments, concentrating on consolidation instead. The *Société Générale*, on the other hand, fully recovered and returned to a more active expansionist

[140] Marianne De Fossé, "Historische stedelijke pakhuizen in Brussel: architectuur en bouw." *Brussels studies*, Algemene collectie, no. 117 (2017): 1-18; *Made in Brussels – Les cahiers de la Fonderie. Revue d'histoire sociale et industrielle de la Région bruxelloise*, no. 49 (December 2013).

[141] L. Genicot, " Études sur la construction des routes en Belgique," *Bulletin de l'Institut de Recherches économiques* 10 (1939), *Bulletin de l'Institut de Recherches économiques et sociales* 12 (1946), and 13 (1947): 423-430, 445-447 and 549; Yves Urbain, "La formation du réseau des vois navigables en Belgique. Développement du système des voies d'eau et politique des transports sous l'Ancien Régime," *Bulletin de l'Institut de Recherches économiques et sociales* 10 (1939): 271-314 ; G. Dejongh and Y. Segers, "Een kleine natie in mutatie. De economische ontwikkeling van de Zuidelijke Nederlanden/België in de eeuw 1750-1850," *Tijdschrift voor Geschiedenis* 114, no. 2 (2001): 171-194.

[142] Bart Van der Herten, *België onder stoom. Transport en communicatie in de 19de eeuw*. Studies in social and economic history 32 (Leuven: Universitaire Pers Leuven, 2004), 292.

[143] Marinette Bruwier, "La vie économique et sociale de Charleroi," In *Industrie et société en Hainaut et en Wallonie du XVIIIe au XXe siècle. Recueil d'articles de Marinette Bruwier*. Crédit Communal – collection Histoire IN-8°, N°94 (Brussels: Crédit communal, 1996), 43.

policy.[144] As will be discussed further, these two financial groups played an important role in the glass industry (including window glass), as they established the two first limited liability companies in this sector.[145]

General trends of Belgian industrialisation in an international context

The general trends of the industrial development of Belgium between its independence in 1830 and the outbreak of the First World War in 1914 can be summarised as follows. In the long run, the industrial output resulted in a steady absolute growth. If the industrial production of 1831 is taken as an index value of 200, this value amounted to 1000 in 1880 and 3,000 by 1913. Nevertheless, this development can be divided into various phases (or cycles).[146]

The first phase, running from 1831 to approximately 1848, started somewhat hesitantly due to the loss of the Dutch market, including the vast colonial market. After the final recognition of Belgian independence by the Netherlands in 1839, the Belgian government struggled with the establishment of trade treaties with neighbouring countries, as the protectionist spirit was still widespread. A treaty with the Zollverein (German customs union) was reached in 1844.[147]

The political troubles of 1848 caused an acute crisis in the whole of Europe. Although Belgium itself did not experience any revolutionary activities, panic in various European capitals, including Paris, affected business in Belgium as well. However, the crisis of 1848 actually heralded a new phase of strong economic growth. The founding of the National Bank of Belgium in 1850, moreover, assured monetary stability for the following decades.[148]

This new phase of economic development lasted until the outbreak of the Franco-Prussian war in 1871. The growth phase from approximately 1850 to 1870 was mostly based on the expansion of the railway network in Belgium as well as in other foreign countries, whereby the production of rails and locomotives greatly increased. Consequently, it was a 'golden age' for coal mining and metallurgy as well. Nevertheless, relatively short-lived crises and depressions occurred during this phase as well. A crisis from 1857 to 1859 was caused by the speculative bubble in the USA, which caused the international credit crises, also affected by war activity in Italy in 1857. Another severe yet short-lived crisis was caused by the bankruptcy of the English bank Overden, Gurney and Co. on 10 May 1866. The monetary impact was so severe that industrial production declined, for the first time since 1848, in 1867. A spectacular economic resurgence occurred already in 1869, but this came to an

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[144] Van der Wee, "The Industrial Revolution in Belgium," 64-77; Bart Pluymers and Suzy Pasleau, "Het kleine België: een grote industriële mogendheidn", In *Nijver België: het industriële landschap omstreeks 1850*, eds. Bart Van der Herten, Michel Oris and Jan Roegiers (Deurne: MIM/Gemeentekrediet van België, 1995), 33-37.
[145] Massart, *Histoire des verreries et des décorateurs*, 20-21; Engen, *Het glas in België*, 194.
[146] Erik Buyst, "De evolutie van het Belgisch bedrijfsleven, 1850-2000,"In *Nijver België: het industriële landschap omstreeks 1850*, eds. Bart Van der Herten, Michel Oris and Jan Roegiers (Deurne: MIM/Gemeentekrediet van België, 1995), 355-363; K. Veraghert, "Conjunctuurbewegingen 1830-1914," In: Vol. 12 of *Algemene geschiedenis der Nederlanden*, ed. Dick Peter Blok (Haarlem: Fibula-Van Dishoeck, 1977-1983), 12-14.
[147] Veraghert, "Conjunctuurbewegingen 1830-1914," 13.
[148] Ibidem, 13.

abrupt end at the outbreak of the war between the two main trading partners of Belgium: France and Prussia.[149]

In contrast to the previous phase, the phase between approximately 1870 to 1890 can be regarded as one of semi-permanent depression, with the lowest points being from 1874-1876, 1884-1885 and 1889-1891, only interrupted by short-lived periods of resurgence. The reasons for this were both external and internal. Externally, the position of the Belgian metal sector in the international market became threatened by the competition of new industrial centres that developed in the German Ruhr region, Northern France, and Luxemburg. Internally, the old industrial areas of Wallonia started to show signs of obsolescence. The ore deposits became largely exhausted, while the first signs of exhaustion of the Walloon coal mines started to manifest as well. The year 1886 signified a nadir in the economic situation, as it marked the international overproduction crisis that hit the United Kingdom, France, Belgium, Germany, as well as Austria, Russia and Italy.[150]

The situation improved during the last phase, between approximately 1895 and 1914. The resurgence was due to two prime factors: the emergence of the new technologies related to the Second Industrial Revolution, and the expansion of foreign markets. As for the former, the application of electricity in industry as well as the development of the chemical sector provided new incentives. Within the metallurgy sector, the Thomas method was introduced. As for the latter, Belgium developed a very active investment policy in Egypt, China and Russia and other foreign countries. The colony of the Congo provided opportunities for investments, particularly in railway construction, while being exploited for its natural resources. This phase of general growth experienced periods of crisis as well. In 1900, the Belgian industry had been hit by the overproduction and overcapacity crisis. In 1907, a financial crisis in the USA reached Belgium as well. Moreover, some fundamental problems started to become apparent in the early 20th century. Despite some developments in the electrical power industry, this sector started to lag behind foreign competitors. The situation was even worse in the emerging automotive sector. Despite there being some production of automobiles, the banking sector did not show much interest. In general, the Belgian economy relied too much on the old established sectors of the First Industrial Revolution (coal mining, steel, steam engines), while the application of the new sectors of the Second Industrial Revolution (electrical power technology, internal combustion engines, automotive industry) remained limited when compared to foreign countries, although they were certainly not entirely absent.[151]

On the other hand, more recent literature, such as an article by Ron A. Boshma, provides a more optimistic assessment of the emerging sectors, such as the electrical engineering and automotive/internal combustion engine industries in Belgium from the late 19th century up to the First World war.[152] Focusing on trade, an article by Michael Huberman, Christopher M.

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[149] Ibidem, 15.
[150] Ibidem, 16.
[151] Buyst, "De evolutie van het Belgisch bedrijfsleven", 355-363; Veraghert, "Conjunctuurbewegingen 1830-1914", 16-19; Georges De Leener, *L'Organisation syndicale des chefs d'industrie. Étude sur les syndicats industriels en Belgique*, Vol. 1, *Les faits* (Brussels and Leipzig: Misch & Thron, 1909), 51.
[152] Ron A. Boschma, "The rise of innovative industries in Belgium during the industrial epoch," *Research Policy* 28 (1999): 861-864.

Meissner and Kim Oosterlinck emphasises the innovative character of Belgian exports in the late 19th century, whereby the innovative and technological products, such as tramway vehicles, accounted for an important part of the strong increase in Belgian exports in general. This contrasts with the traditional view that Belgian industry remained largely focused on semi-finished goods. Moreover, the authors suggest that these modern, high-technology industrial sectors, such as the production of tramway vehicles, showed strong productivity growth in the late 19th century, implying that the Belgian economy had been more dynamic and innovative than previously assumed. However, the modest rate of growth in more traditional sectors, such as textiles, did offset the development of new sectors.[153]

Last but not least, it should be noted that the Belgian economy in general was very strongly export-oriented (more on this in the chapter on Belgian foreign trade policy). In fact, by the early 20th century it could be described as the most export-oriented economy in the world. As a consequence, it was very prone to the economic conjuncture in foreign countries.[154]

Chapter 1.3: Charleroi and the Centre

As already mentioned, the regions of Charleroi and the Centre were two of the five major industrial growth poles of 19th-century Belgium, alongside Ghent, Liège and the Borinage (Mons). As these two regions housed the lion's share of the Belgian window-glass industry, they will be discussed in more detail in the present chapter, while industry, infrastructure and urban development will also be taken into account. Most attention will be given to the Charleroi region, as it hosted the most window-glass factories. The Centre, while possessing fewer factories, housed one very important factory.

Charleroi

The (proto-)industrial history of the region of Charleroi stretches back at least several centuries. Paradoxically, it even pre-dates the founding of the city itself, which was only recognised as such in 1666. For several centuries, up to the second half of the 20th century, coal mining, metallurgy and metalworking, and glass industries remained dominant within the region's economy, while some other industries developed as well.[155]

Coal mining was practised in the region from the late 13th century onwards.[156] Apparently, the earliest mention of coal mining dates back to 1251, in the village of Gilly. It formed a basis for the production of spikes, a branch of the metal industry typical of the region from the Middle Ages, being described as 'flourishing' in the 15th century. The third of the traditional industries, glass production, was mentioned for the first time within the region in

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[153] Michael Huberman et al., "Technology and Geography in the Second Industrial Revolution: New Evidence from the Margins of Trade," *The Journal of Economic History* 77, no. 1 (March 2017): 42-45, 69-71.

[154] Kristof Van De Velde, "De Staat en de organisatorische uitbouw van de Belgische buitenlandse handel, 1916-1926," *Revue belge de philologie et d'histoire* 81, fasc. 4. Histoire medievale, moderne et contemporaine (2003): 1167-1170; Huberman et al., "Technology and Geography," 42; Paul Bairoch, *Commerce extérieur et développement économique de l'Europe au XIXe siècle*. Civilisations et Sociétés 53 (Paris and the Hague: Mouton, 1976), 258-286.

[155] Bruwier, "La vie économique et sociale de Charleroi," 37-77.

[156] Laurent Dechesne, *Histoire économique et sociale de la Belgique depuis les origines jusqu'en 1914* (Paris and Liège: Librairie du Recueil Sirey and Librairie Joseph Wykmans, 1932), 208.

1438.[157] The importance of the spikes industry exceeded the regional or even 'national' scale, as in the late 18th century spikes from the Charleroi region were already being exported to the Dutch Republic for shipbuilding. The (window-) glass industry developed in close association with coal mining in the 18th century as well. In the 17th and 18th centuries, most collieries were located in the so-called Faubourg de Charleroi, a suburb located *extra muros* to the north of the city proper, as well as in the neighbouring villages of Gilly, Lodelinsart, Jumet, Châtelineau, Montignies-sur-Sambre and Dampremy, among others.. The construction of a paved road, the *Chaussée de Bruxelles*, between 1713 and 1719, which passed through the Faubourg, stimulated the development of various industries, especially coal mining, as it provided the main transport connection between the regions of Charleroi and Brussels, the main consumption centre.[158]

It goes without saying that the three main industries of the region experienced change, both quantitative as well as qualitative, in the course of the Industrial Revolution from the 18th century onwards. For instance, one of the first Newcomen steam engines in the Charleroi region (and in present-day Belgium) was installed in a coal mine in Lodelinsart near Charleroi in 1735.[159] In metallurgy, the main innovation consisted in the replacement of charcoal by coke. The first coke-fired blast furnace in the region was installed in 1827.[160] The usage of steam engines in coal mining became ubiquitous in the course of the first decades of the 19th century.[161]

New industries emerged in the region in the course of the 19th century as well, especially within the fields of metalworking and engineering. By the late 19th century, the region's industries produced rails, railway locomotives, steam engines, metal constructions, electrical equipment, automobiles, etc.[162] The production of steam engines, used in collieries and other local industries, was of particular importance. In the first decades of the 19th century, most steam engines used in the Charleroi region were produced elsewhere, in the first place in and near Liège (the firms of Cockerill in Seraing and Tassin in Liège being the main suppliers). However, after the period 1835-1840, the number of steam engine manufacturers multiplied within the region itself.[163]

As noted by Marinette Bruwier, the expression *pays de Charleroi* as a designation of the Charleroi region as a specific geographic and economic entity only entered into usage around 1830, despite the fact that the 'industrial identity' of this region (based on coal mining, metallurgy and glass production) emerged at least one century earlier. This economic region largely coincided with the administrative entity of the arrondissement of Charleroi.[164] Its identity as a specific economic region was reinforced by the creation of its own governance

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[157] P.-L. Michotte and M.-A. Lefèvre, *Commentaires de huit cartes échantillons-types des régions géographiques de Belgique* (Brussels and Paris: Office de publicité and Librairie Haitier, 1928), 31.
[158] Bruwier, "La vie économique et sociale de Charleroi," 37-46; Bruwier, "La révolution industrielle," 129-141.
[159] Bruwier, "La révolution industrielle," 83.
[160] Ibidem, 142.
[161] Ibidem, 145-147.
[162] Marinette Bruwier, "L'industrialisation en Hainaut au XIXe siècle." In *Industrie et société en Hainaut et en Wallonie du XVIIIe au XXe siècle. Recueil d'articles de Marinette Bruwier*. Crédit Communal – collection Histoire IN-8°, N°94 (Brussels: Crédit communal, 1996), 353.
[163] Bruwier, "La révolution industrielle," 146.
[164] Ibidem, 129-130.

body, the Chamber of Commerce, in 1827.[165] The region was known as the *pays noir* (black country) as well. The *Pays de Charleroi* was located on the intersection of two main economic axes of 19th-century Belgium, the east-west (Mons–Charleroi–Liège) industrial axis ('sillon industriel'), determined by the presence of coalbeds, and the north-south (Antwerp–Brussels–Charleroi) axis (ABC-Axis), determined by the development of transport infrastructure. According to the Charleroi historian, Jean-Louis Delaet, the *pays de Charleroi* encompassed 39 communes and had an area of approximately 300 square kilometres.[166]

A monograph on the various geographic regions of Belgium by P.-L. Michotte and M.-A. Lefèvre published in 1928 mentioned that the agglomeration of Charleroi consisted of 17 communes. Unfortunately, no list of the communes was provided. However, it seems that Michotte and Lefèvre referred to the core of the administrative arrondissement of Charleroi. According to this work, the total population of this agglomeration grew from 63,666 in 1846 to 263,406 in 1910. Clearly, despite the old industrial tradition, the urbanisation of this region largely took place during the second half of the 19th century. Despite the strong demographic growth, the region remained decentralised. As the centre of the region, Charleroi was actually smaller than some of its suburbs. In 1928, only one of the 17 communes, Jumet, had more than 30,000 inhabitants, while three (including the city of Charleroi itself) had more than 25,000, two more than 20,000, eight more than 10,000 and three more than 5,000. Even in the early 20th century, the region still resembled a poorly structured patchwork of factories and habitations, still bearing traces of its rural character.[167]

In his monograph on the urbanistic and industrial development of the Charleroi region (1952), Maurice Pirsoul described the *pays de Charleroi* as defined by the location of coal first and foremost. This is indicative of the fact that coal mining remained the basic industry within the region even into the mid-20th century. According to Pirsoul, the region encompassed 41 communes, that is, 39 communes of the administrative arrondissement of Charleroi and two communes (Anderlues and Jamioulx) of the arrondissement of Thuin (Figure 4). In this regard, the industrial region was basically synonymous with the coal field.[168]

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[165] Fred Stauder, *La Chambre de Commerce et des Fabriques de Charleroi (1827-1875). Une institution publique du Hainaut belge méridional* (Antwerp: n. p. 2021 [unpublished manuscript provided by e-mail]), 19, 25.
[166] Jean-Louis Delat, "Charleroi une ville-territoire," in: *Charleroi, Mons, Valenciennes. Villes de la frontière*, ed. Maurice Culot (Paris: Institut français d'architecture, 2001), 115-155.
[167] Michotte and Lefèvre, *Commentaires de huit cartes,* 29-33.
[168] Maurice Pirsoul, *Phénomène urbain dans la région de Charleroi* (Charleroi: Heraly, 1952), 14.

Figure 4: The Charleroi region as defined by Pirsoul

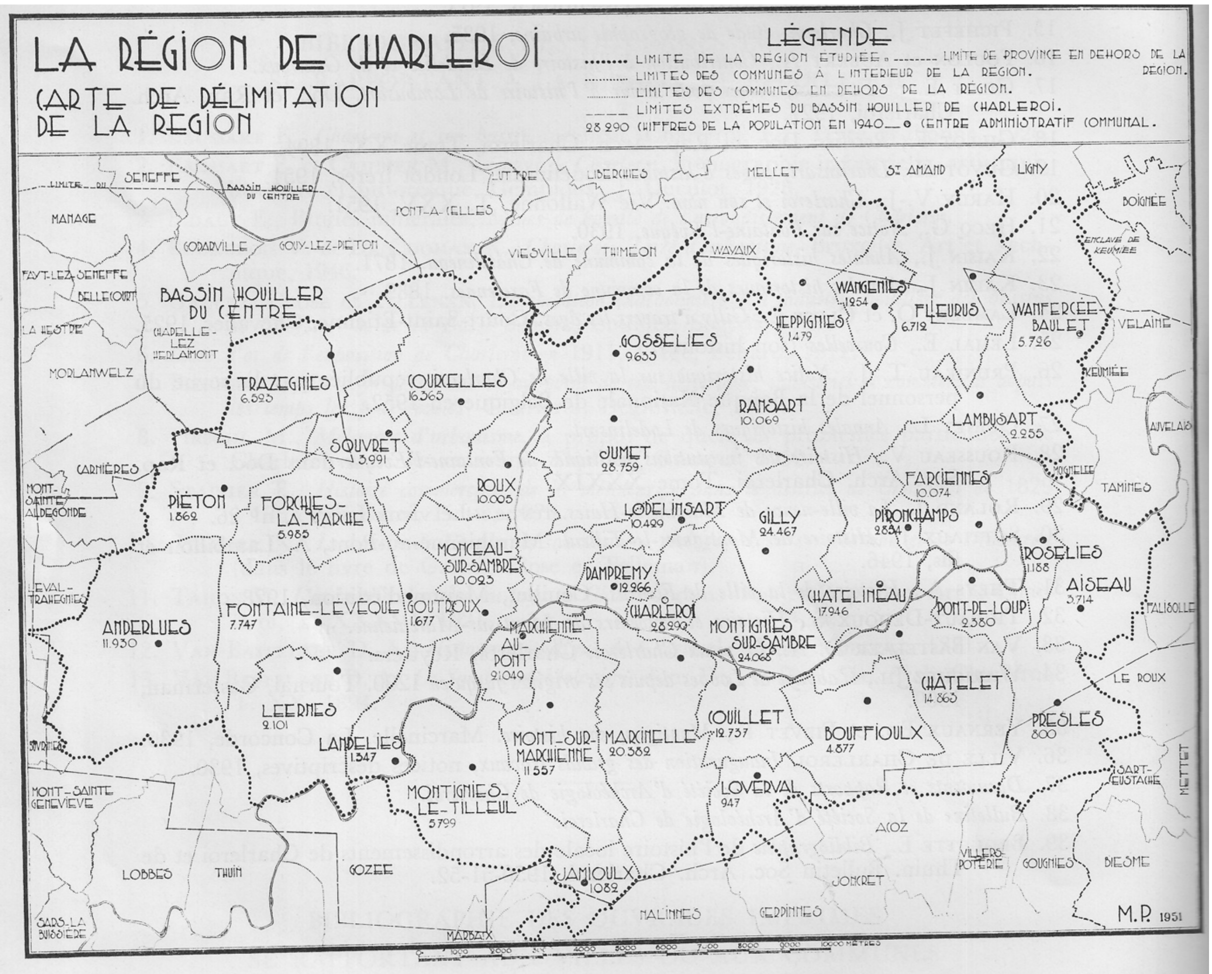

Fig. I. *Carte de délimitation de la région de Charleroi.*

Source: Pirsoul, Phénomène urbain dans la région de Charleroi

A narrow entanglement of rural and industrial economic activities was typical for this region already during the *Ancien Régime*, as no clear-cut spatial distinction between agricultural areas and (proto)industrial enterprises, such as collieries and spike forges, can be drawn.[169] The city of Charleroi (Charleroy in old orthography, used until the early 19th century) proper was established in 1666 as a fortress on the site of the old village of Charnoy.[170] Hence, the city was established 'artificially' as a military centre primarily. Nevertheless, it had a profound effect on the urbanisation pattern of the region that was to become the *pays de Charleroi*. Before 1666, the region lacked any true urban centre. It had a few *bourgs* (Fleurus, Châtelet, Fontaine-l'Evêque, Gosselies and Marcienne-au-Pont) that could be regarded as local rural centres, yet these definitely could not be counted as cities or even towns. With the emergence of Charleroi, the region received a clear 'central place' for the first time.[171]

169 Ibidem, 10.
170 Elie Baussart, *Charleroi et son bassin industriel* (Charleroi: La terre wallonne, 1926), 7-11.
171 Pirsoul, *Phénomène urbain,* 61-67.

Being a military fortress first and foremost, Charleroi proper did not possess many industrial functions. In the 17th century, it consisted of two parts, the *ville haute* that had military, administrative and commercial functions, and the *ville basse* that possessed some small-scale artisanal activities. Both parts were fortified (albeit *ville basse* to a lower degree). In the 17th and, especially, 18th centuries, industrial activities developed in the Faubourg de Charleroi. Being located *extra muros*, the Faubourg had more in common with the surrounding 'industrial villages' of Gilly, Montignies-sur-Sambre, Lodelinsart and Dampremy than with the city of Charleroi proper (Charleroi *intra muros*).[172] Coal mining and glass production developed in the Faubourg in close association from the late 17th century onwards. For instance, the first glass factory was established there in 1669.[173]

Despite functioning as a centre of its region, the city of Charleroi always remained small when compared with other industrial centres in Belgium. For a long time, growth was hindered by the fortifications. Yet even when the 'old' fortifications were demolished in 1747, the city remained small, with only 3,563 inhabitants in 1784. Moreover, the city became a fortress again in 1816.[174] These 'new' fortifications hindered the demographic growth as well as the industrial development of the city for decades, until their final demolition in 1871.[175] Hence, whenever literature mentions industry in Charleroi, in most cases this should be interpreted as industry located in the surroundings of the city (the Faubourg and neighbouring communes such as Jumet or Lodelinsart) rather than in the city itself.

The 'dispersed' (or even 'amorphous') character of the urbanisation (and, consequently, industrialisation) of the Charleroi region can be illustrated by a comparison with another prominent industrial region, Liège, as provided by Pirsoul. In 1947, the total population of the Charleroi region (41 communes) amounted to 379,164, while Charleroi city with only 25,894 inhabitants, ranked second after Jumet with 28,569. Hence, the population of Charleroi proper only represented 6.8% of its own region. For Liège, the picture was quite different. The population of the entire industrial region of Liège (defined by Pirsoul as 40 communes plus Liège itself, not to be confused with the administrative province of Liège) amounted to 456,386, while Liège ranked first with 156,208 inhabitants, that is, 34.2% of the population. While the numbers refer to the later period (1947), the general pattern must be relevant to the earlier period as well.

Pirsoul explained the striking difference between the two regions by their distinct historic developments. Indeed, Liège had been a dominant urban centre with many industrial activities (weaponry being the most famous) since the Middle Ages, while the region of Charleroi had been characterised by a network of the aforementioned semi-urban *bourgs*. Being established in 1666 almost *ex nihilo*, Charleroi had never developed into a large city, despite its central role within the region.[176] Hence, the mere absence of a large dominant urban centre (as opposed to the example of Liège) assured that the industrialisation of the

[172] Ibidem, 67-68.
[173] Bruwier, "La vie économique et sociale de Charleroi," 37-38.
[174] Pirsoul, *Phénomène urbain,* 69-73.
[175] Delaet, "Charleroi une ville-territoire," 115-155.
[176] Pirsoul, *Phénomène urbain,* p. 110-111.

Charleroi region took a ‘suburban’ or ‘semi-urban’ form from the start. During the 19th century, the main pattern of industralisation and urbanisation remained largely unplanned and ‘anarchistic’. The division between industrial and residential areas only started to occur in the early 20th century, due to the growing size of factories. Moreover, any attempts towards urban planning were undertaken in the city proper only, while the development of other communes remained largely unplanned.[177] Even describing the situation of the 1930s, Pirsoul spoke of an ‘anarchic interweaving of factories and dwellings.[178] While he did not use that term, this can be seen as a remarkable example of path dependency. Recent literature on the urban geography of Charleroi still upholds the vision formulated by Pirsoul, was as well as other authors, whereby the entire region is described as characterised by a complex and (largely) unplanned process of urbanisation and industrialisation, resulting in a patchwork (or ‘chaotic network’) of dwellings, factories, railways and roads.[179]

The transport infrastructure remained deficient in the region for a long time. Before its canalisation, the Sambre river (a tributary to the Meuse river, emerging in the present-day French Aisne department and flowing eastward towards Namur) that passed through the region, presented poor navigation conditions. Various hydrographic works, such as barrages and primitive locks, were constructed along the river from the late Middle Ages onwards. However, these interventions, being conducted by various feudal lords, were uncoordinated. Moreover, many of them served mills, rather than navigation. Therefore, according to a report drawn by a certain Franquet in the mid-18th century, the river was only navigable for small boats of 15 to 20 tons. The situation remained largely unchanged (that is, problematic) until the early decades of the 19th century.[180] In fact, the deficient transport infrastructure actually stimulated colliery owners to engage in other industries, such as metallurgy and glass production in the 17th and 18th centuries, thus integrating coal mining with these two fuel-intensive industries. In this way, a part of the region’s coal production could be used on the spot without need for further transport.[181]

The situation became somewhat alleviated by the construction of paved roads (*chaussées*) in the 18th century. In particular, the aforementioned *Chaussée de Bruxelles* built between 1713-1719 allowed the transportation of coal (as well as other industrial products) to Brussels and Flanders, despite the fact that heavily-loaded carts frequently caused problems.[182] Other paved roads connecting Charleroi to localities such as Sombreffe (further towards Namur), Mons, Philippeville, and Beaumont were created in the 18th and early 19th centuries.[183] The transport situation only improved significantly in the 19th century. In 1832, works on the improvement of the Sambre river from the French border to Namur were finished, allowing boats of up to 270 tons to pass. In the same year, the Charleroi–Brussels canal was inaugurated. However, due to its narrow profile it could only accommodate small,

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[177] Ibidem, 76-79.
[178] Ibidem, 105. Original quote: “l’imbrication anarchique des usines et des habitations”
[179] Cecilia Furlan, “Unfolding Wasteland. A Thick Mapping Approach to the Transformation of Charleroi’s Industrial Landscape,” in *Mapping Landscapes in Transformation. Multidisciplinary Methods for Historical Analysis*, eds. Thomas Coomans, Bieke Cattoor and Krista De Jonge (Leuven: Leuven University Press, 2019), 136-138.
[180] *La navigation en Wallonie* (Liège: Musée de la Vie Wallone, 1978), 35-37.
[181] Bruwier, “La révolution industrielle,” 131.
[182] Bruwier, “La vie économique et sociale de Charleroi,” 43; Bruwier, “La révolution industrielle,” 131.
[183] Delaet, “Charleroi une ville-territoire,” 115-155.

specially built barges known as *baquets de Charleroi*, of 70 tons maximum. It was only by the early 20th century that the canal was adapted to accommodate normal-size barges (known as *péniches*) of 300 tons.[184] Already in 1832 the Charleroi–Brussels canal became connected with the older Brussels–Willebroek–Antwerp waterway in Brussels, thus establishing the Antwerp–Brussels–Charleroi axis (ABC-Axis) for the first time.[185] The Sambre-Oise canal in France, inaugurated in 1839, created a connection between Charleroi and Paris, an important export market for Charleroi coal.[186]

In 1843 Charleroi became connected to the Belgian railway network, when the line running westward from Charleroi to Marchienne-au-Pont, Luttre, Manage and Braine-le-Comte was inaugurated (the same line continued eastward from Charleroi to Namur). In Braine-le-Comte it joined the already existing railway line, Brussels–Mons, hence assuring the railway connection between Charleroi and Brussels. This line was constructed and operated by the Belgian State. The State Railways were called *État Belge*, or quite often just *État* for short.[187] Another particularly important railway line connecting Charleroi with Leuven was first built by the private railway company *Chemin de fer de Louvain à la Sambre* and was inaugurated in 1855. After a few ownership changes, it became amalgamated into the private railway company *Grand Central Belge* in 1864.[188]

After the first state-owned and state-operated line, more private lines were constructed by various concessionaries.[189] These were (in chronological order) the following:[190]

- To Marchienne-au-Pont and Walcourt (1848) and further from Walcourt to Vireux (1854)
- To Erquelinnes on the French border (1852) and from Erquelinnes to Paris (1855)
- To Leuven (1855), aforementioned
- To Châtelineau and Morialmé (1855) and further from Morialmé to Givet (1862)
- To Marchienne-au-Pont and Baume (1865)

As it appears, many of these lines passed through Marchienne-au-Pont, an 'industrial suburb' of Charleroi. In fact, the station of Machienne-État was designated as the first-class station in 1863. The only other station in Belgium that could be compared to Marchienne-État in terms of importance for freight transport, was that of Antwerp.[191]

Within the context of the window-glass industry, the Charleroi–Leuven line (*Grand Central Belge*) was the most important, as it assured a direct connection with Antwerp, the main export port. Moreover, it passed through the communes of Jumet and Lodelinsart, where

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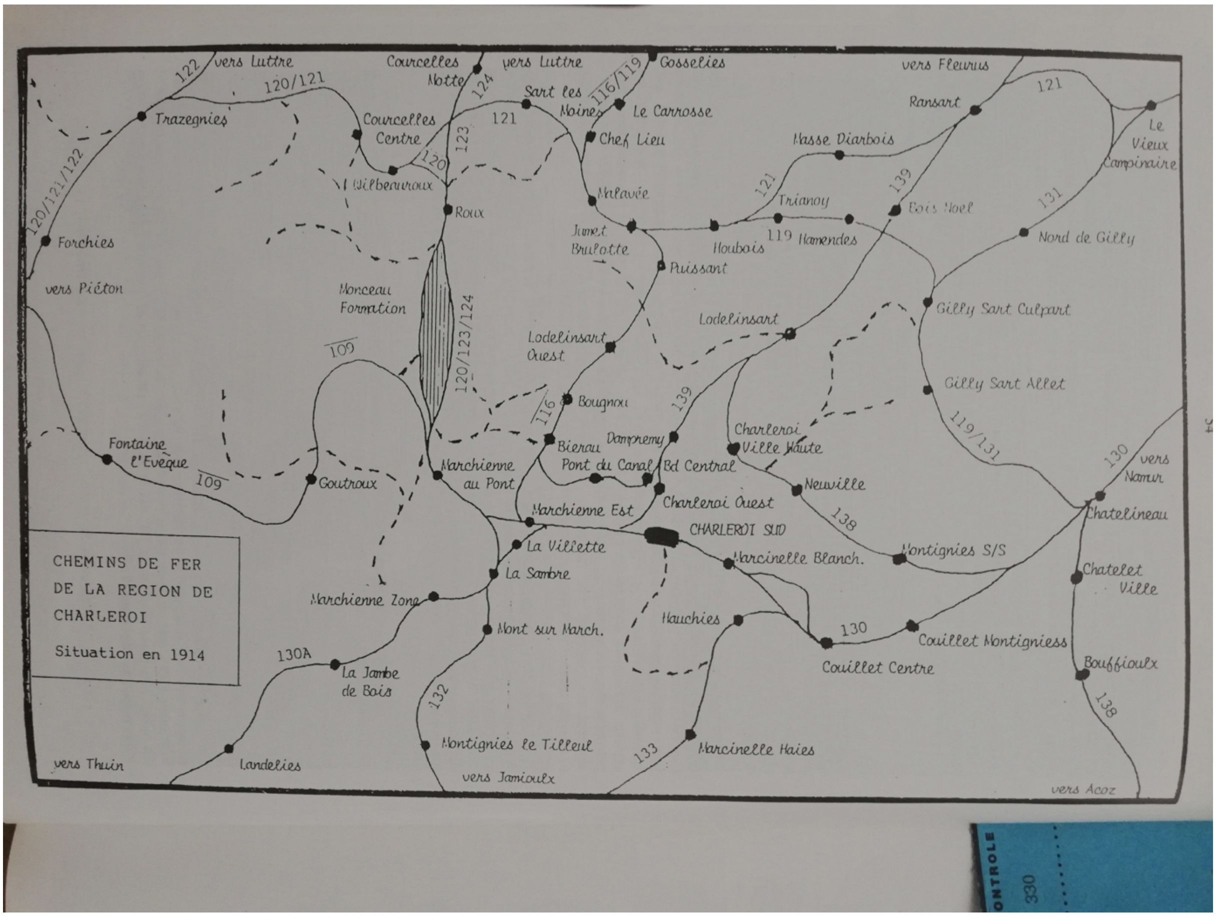
[184] *La navigation en Wallonie*, 36-40.
[185] De Caigny, "New Economic Geography als bedrijfshistorische invalshoek," 538-539.
[186] Delaet, "Charleroi une ville-territoire," 115-155.
[187] Jacques Morue, "Les chemins de fer et l'État Belge," in *1843 – 1993. 150 ans de rail à Charleroi* (Brussels: Édition PFT, 1993), 35-41.
[188] Jacques Morue, "Le Grand Central Belge," in *1843 – 1993. 150 ans de rail à Charleroi* (Brussels: Édition PFT, 1993), 63-76.
[189] Morue, "Les chemins de fer et l'État Belge," 41-47.
[190] Delaet, Jean-Louis, "Les chemins de fer et Charleroi," in *1843 – 1993. 150 ans de rail à Charleroi* (Brussels: Édition PFT, 1993), 19.
[191] Ibidem, 19.

most window-glass factories were located. However, as will be discussed further, the level of service provided by this private railway left a lot to be desired.

Overall, a complex, almost maze-like railway network emerged in the second half of the 19th century, consisting of public railway lines as well as industrial branch lines, connecting individual factories to the mainline railways. A detailed study of this network would be beyond the scope of the present study. The Figure 5 below gives an impression.

Figure 5: Railway network of the Charleroi region. Industrial rail lines in dashed lines.



Source: Morue, "Le Grand Central Belge", in: *150 ans de rail à Charleroi* (Brussels, 1993), 63-76.

The Centre

From the 1830s onwards, a new industrial region started to emerge between Borinage (Mons) and Charleroi around the present-day town of La Louvière, known as the Centre (le Centre). The name Centre first appeared in 1832 when a coal mining society, *Charbonnages du Centre* (meaning literally 'Collieries in-between', that is between Mons and Charleroi), started to operate there. Two factors were crucial to the emergence and development of this industrial region. Alongside the coal mining activities, the digging of the aforementioned Brussels-Charleroi canal, inaugurated in 1832, was of major importance. From 1855 onwards, the Administration of Mines started to make a distinction between the coal mining regions of

Couchant de Mons (Borinage) and Centre, thus designating the Centre as a distinct geographical entity for the first time, if only for a very specific context (coal mining).[192]

Compared to the Charleroi region, the Centre had always been even more ‘amorphous’ in many respects. It lacked a major urban centre, as the town of La Louvière could hardly be described as such. Neither did it possess any formal administrative structure, as its territory was divided between the arrondissements of Charleroi, Mons, Soignies and Thuin.[193] As will be discussed later, the region lacked its own chamber of commerce as well. The limits of the region had not been clearly defined either. By the early 20th-century, the ‘core’ of the region consisted of the (present-day) communes of La Louvière, Binche, Morlanwelz, Manage, Chapelle-lez-Herlaimont and Anderlues.[194] While never being a true administrative entity, the region of Centre received an official status in 1998 as an Urban Community of Centre (*Communauté Urbaine du Centre, CUC*), an inter-communal cooperation organisation aiming at the social and economic development of twelve participating communes, namely Anderlues, Binche, Braine-le-Comte, Chapelle-lez-Herlaimont, Ecaussines, Estinnes, La Louvière, Le Roeulx, Manage, Morlanwelz, Seneffe and Soignies.[195] It should be noted that these present-day communes comprise a large number of (up to sixty)multiple municipal reforms.[196]

Unlike other industrial regions of 19th-century Belgium, the Centre lacked a large city with an old industrial tradition, save for some small-scale industrial activities in the smaller towns, such as glass production in the town of Seneffe. In general, the region remained largely rural up to the beginning of coal mining in the 1830s. Even as late as 1928, a monograph on the various geographic regions of Belgium described it as very different from the intensely industrialised region of Charleroi, a literal countryside (*campagne*) dotted with collieries, but still rural in many respects. According to this work, industrial activities in this region remained almost exclusively limited to coal mining.[197] This assessment is somewhat too harsh, however. While coal mining undoubtedly remained the most important within the region, many other industries emerged and developed in this region in the course of the 19th century. Alongside the glass industry, which will be discussed further, these included stone quarries (the famous *pierre bleue* or *petit granit*, popular in the 19th-century architecture and sculpture, in Soignies, Ecaussinnes and Seneffe), ceramics (for example, *Faïencerie Boch* in La Louvière) and mechanical engineering, including railway rolling stock (for example, *Baume & Marpent* in Haine-Saint-Pierre and *Nicaise-Delcuve* in La Louvière).[198]

As already mentioned, the Charleroi-Brussels canal was the ‘lifeline’ of the region. Strictly speaking, the canal itself did not truly penetrate deeply into the Centre region. However, multiple branches, starting at Seneffe and serving Bellecourt, la Croyère, la Louvière and Houdeng were inaugurated shortly after the main canal. Moreover, between 1888 and 1917, the *Canal du Centre* was built, connecting Mons with Seneffe on the Charleroi–Brussels

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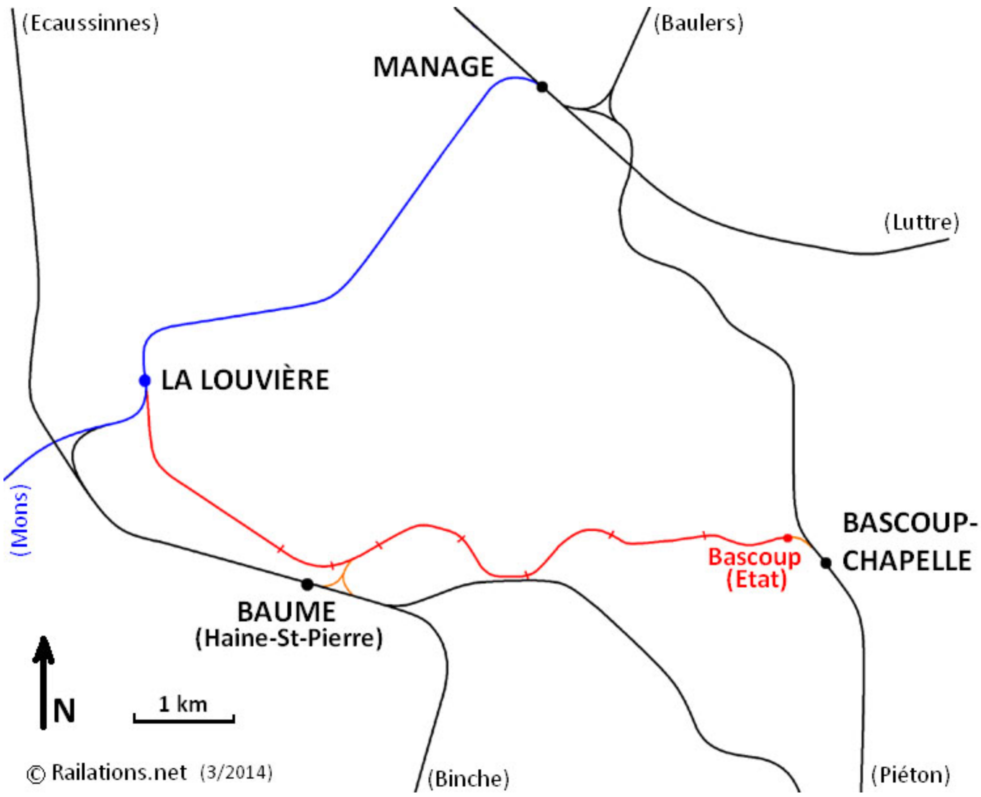
[192] Sirjacobs, *Le Centre,* 6-10; Massart, *Histoire des verreries et des décorateurs,* 9.
[193] Ibidem, 9
[194] Sirjacobs, *Le Centre,* 6-7.
[195] Communauté Urbaine du Centre Official website, “À propos de la CUC,” accessed 13 October 2022 https://www.cuc.be/a-propos/
[196] Massart, *Histoire des verreries et des décorateurs,* 9.
[197] Michotte and Lefèvre, *Commentaires de huit cartes,* 33.
[198] Sirjacobs, *Le Centre,* 6-10.

canal, thus creating a direct connection between Charleroi and Mons through the Centre.[199] Nowadays, it is mostly known for its four historic boat lifts, recognised as a World Heritage by the United Nations Educational, Scientific and Cultural Organisation (UNESCO).[200]

The region of the Centre became well-served by a railway in 1848-1849, when a railway line built by the private railway company *Chemin de fer de Namur à Liège et de Mons à Manage* was inaugurated. The Mons–Manage line ran from Manage to Mons though the Centre, including La Louvière. In Manage and Mons respectively, it connected to the already-existing State railway lines. Later, more railways were built in the region. For example, the La Louvière–Baume (Haine-Sait-Pierre)–Bascoup-Est line, built already in 1848 by the same company responsible for the aforementioned Manage–Mons railway line, served various industries (colliers most and foremost), including the *Verreries de Mariemont* (Figure 6).[201]

Figure 6: Primary railway lines of the Centre region



Source: Railations.net, with permission, https://www.railations.net/lalouvierebascoup.html

[199] *La navigation en Wallonie*, 39-42.
[200] UNESCO World Heritage official website, "The Four Lifts on the Canal du Centre and their Environs, La Louvière and Le Roeulx (Hainaut)," accessed 25 October 2022 https://whc.unesco.org/en/list/856/
[201] Railations, "LA LOUVIÈRE - BASCOUP (Etat)," accessed 13 October 2022. https://www.railations.net/lalouvierebascoup.html
; Belgische spoorlijnen, "Lijnen 111-120," accessed 13 October 2022. https://sites.google.com/view/belgischespoorlijnen/spoorlijnen/111-120

Export outlets

As already mentioned, the port of Antwerp was the main export gateway of 19th-century Belgium. The main connection between the Belgian window-glass industry and Antwerp was assured by the *Grand Central Belge* railway, as implicitly attested to by the *Association*'s proceedings, mostly in the context of problems encountered (bad treatment of glass by the railway company). Similar problems (bad treatment and theft of glass) were reported for the port of Antwerp as well on multiple occasions. The *Association* even had to appoint an '*agent'* (Ducoffre) in order to keep a close eye on the situation (Part 2 Chapter 2.2). At least from 1886 onwards, the diversification of exports of glass from the port of Antwerp to the port of Ghent took place, also attested to by a report of the aforementioned *agent* Ducoffre.[202]

From the early 1890s, Terneuzen (which was, in fact, located in the Netherlands, yet functioned as Ghent's outport) started to feature in the *Association's* proceedings as an export port alongside Ghent and Antwerp. The exact reasons for this redirection are not known, yet the conflict with the railway company *Grand Central Belge* in the early 1890s seems to have been at least one of the reasons. Unfortunately, there is no quantitative data on the relative importance of these ports for the exports of glass. The action circle of Ducoffre expanded as well, as the proceedings mentioned his trips to Ghent and Terneuzen, revealing implicitly that he was still based in Antwerp.[203]

In 1896, Ducoffre addressed a letter to the *Association*, asking to re-establish his post in Antwerp. The *Association* did not accept his proposal but remarked that it would be useful to establish surveillance in Terneuzen, where glass was 'treated without due attention'. This remark indicates the remaining importance of this (Dutch) port even after the settlement of issues with the *Grand Central Belge*, that had led to the redirection of a part of the exports there from Antwerp in the first place.[204]

Chapter 1.4: The development of the Belgian window-glass industry until 1914

This chapter presents an overview of the development of the Belgian window-glass industry from the later 18th century, when this industry became firmly established within the Charleroi region, up until 1914. The purpose of the chapter is twofold. On the one hand, it is intended to expose general trends that form the necessary background for the understanding of Parts 2 and 3, which are arranged by topic rather than chronology. On the other hand, it provides the broader international context, such as the development of the window-glass industry in other countries. Indeed, as the Belgian window-glass industry was very much export-oriented, information on the international situation is required for a better understanding of developments within Belgium.

Because of this, a certain degree of information overlap with the following chapters was unavoidable. For instance, topics such as the technological developments and detailed geographical distribution, will be discussed in more detail in the following chapters.

[202] Private archive Gobbe, Association, Brouillons II, Séance du 17 décembre 1886
[203] Private archive Gobbe, Association, Originaux C, Assemblée Générale 18 août 1893
[204] Private archive Gobbe, Association, Originaux C, Assemblée Générale 31 décembre 1896

Despite its ‘general’ and ‘introductory’ character, this chapter provides much more than a mere compilation based on literature, as it already makes use of multiple published and unpublished primary sources. In particular, much of the information on the international situation and the general state of the industry was derived from the unpublished reports of the *Association*, that were inscribed into the proceedings. Contemporary press was used as well, in particular in relationship to the curious case of the (failed) attempt to establish a ‘Belgian’ window-glass factory in Japan. To my knowledge, this case has never been discussed in literature before. Moreover, various sources, published and unpublished, Belgian and foreign, were used to tackle the important question of the comparative advantage of Belgium on the international market. Those included contemporary published treatises, reports of the Charleroi Chamber of Commerce and the Association’s proceedings.

From Ancien Régime to independent Belgium

Between 1790 and 1830 the Southern Low Countries experienced a turbulent period characterised by revolutions, wars and changing political regimes. These political crises and turmoil make it difficult to establish the situation of the glass industry with great certainty, as circumstances changed rapidly and dramatically. It appears nevertheless, that the window-glass industry experienced an expansion after the annexation by France in 1795, as this opened up the large French market. In 1801, the department of Jemappes (the present-day province of Hainaut) possessed eight factories that produced window-glass and bottles. Between 1807 and 1813, four new factories were established in the proximity of Charleroi. One obstacle to this development was Dutch opposition, as the Netherlands had prohibited the export of cullet (‘grosil’, that is glass splinters), that were re-used for the production of new glass, in order to benefit their own industry.[205] It has been claimed that the introduction of the Continental system in 1806 (the embargo on the trade with Great Britain imposed by Napoleon) caused a crisis in the glass industry of then present-day Belgium,[206] but there is insufficient evidence for this claim, as four new factories were erected after this date.

Between 1815 and 1830, the Southern Low Countries (comprising present-day Belgium and Luxemburg) were part of the United Kingdom of the Netherlands. At first, this caused a crisis, as the French market became less accessible. The situation began to improve some time after 1821 due to the opening of the large Dutch colonial market.[207] Moreover, a Royal Decree of 20 August 1823 prohibited the import of all glass products from France, with the exception of mirror glass, which effectively protected the domestic industry from the most important competitor.[208] The industry progressed steadily in the 1820s. Between 1823 and 1829, the number of window-glass factories in then present-day Belgium increased from ten to 23, while the total production rose from 8,096 to 19,756 ‘caisses’ (crates).[209]

[205] Roger Darquenne, *Histoire économique du département de Jemappes* (Mons: Cercle archéologie de Mons, 1965), 171-179.
[206] Mac Lean, “Gegevens over de Nederlandse en Belgische glasindustrie,” 109.
[207] Engen, *Het glas in België*, 193; Lefèbvre, *La verrerie à vitres*, 39.
[208] Mac Lean, “Gegevens over de Nederlandse en Belgische glasindustrie,” 121.
[209] Douxchamps, “L’évolution séculaire de l’industrie du verre à vitres,” 472.

Belgian independence in 1830 did not cause much hindrance to the window-glass industry. On the contrary, the steady growth of production continued, while Belgium started to play a major role on the international market. The global demand for window-glass rose spectacularly in the course of the 19th century due to population growth, increasing urbanisation and changes in architecture. Generally, modern urban houses had larger windows than traditional rural dwellings, while the iron-and-glass architecture (shopping arcades, train stations, greenhouses and the like) started to appear, further increasing the demand for glass.[210]

The golden age of global leadership

Already in 1839, Belgium exported window glass to the Netherlands, England, Germany (hanseatic cities and Hanover), Denmark, Russia, Sweden, Norway, Turkey, Dutch Indonesia and the United States.[211] The rapid expansion of window-glass production and export in Belgium between 1830 and 1855 can moreover be attributed to a decrease in the price of glass. Curiously, the exact reason for this decrease is unclear. In his quantitative study, Yves Douxchamps stated speculatively that a changing labour organisation, with more division of labour, could have been a reason. Unfortunately, available sources provide no information on this matter. Another important factor was the lowering of transport costs due to the development of steamships. To give an indication, the transport cost of one ton of cargo from Antwerp to New York declined from 78 to 21,75 Belgian francs between 1822 and 1850. After 1855, the selling price of glass remained generally stable, but exports expanded, as the economic development and rising wealth in various countries made window-glass accessible to the ever increasing number of consumers. The total production rose from 1.28 million m^2 in 1840 to 23.47 million m^2 in 1900, while approximatively 95% was exported.[212] In 1892, for instance, total production amounted to 144,000 tons, of which 133,300 tons (92.6%) was exported, leaving only 10,700 tons (7.4%) for domestic consumption.[213]

The dynamics of export between 1840 and 1914 can be divided into three periods. During the first period, stretching from 1840 to 1873, the annual growth rate of exports was as high as 9%. This was the true 'golden age' when foreign competition was of very little concern. The growth rate declined to 5% between 1873 and 1884 and to a mere 2.23% between 1884 and 1890. The declining rates of export growth are indicative of growing international competition, as well as of internal problems of the industry.[214]

Throughout the 19th century, Belgium remained one of the most important producers of window glass on the global market. Its position can even be described as dominant until approximately 1880. The most important competitors were France, England, Germany and the United States. France had an old tradition of glassmaking, too. In the first half of the 19th

[210] Christian Mille, "Évolution de la branche verre plat en France et en Europe – Progrès technique et stratégies d'entreprises" (Unpublished PhD thesis (doctorat), Université de Paris I – Pantheon Sorbonne, 1982), 73-75.
[211] Xavier Heuschling, *Essai sur la statistique générale de la Belgique, composé sur les documents publics et particuliers* (Brussels: Vandermaelen, 1844), 56-83.
[212] Douxchamps, "L'évolution séculaire de l'industrie du verre à vitres," 512; Engen, *Het glas in België*, 194; Chambon, *L'histoire de la verrerie en* Belgique, 198.
[213] Private archive Gobbe, Association, Originaux C, Assemblée Générale 11 août 1893
[214] Douxchamps, "L'évolution séculaire de l'industrie du verre à vitres," 474.

century, most French window-glass factories were situated in the Massif Central, *Verreries de la Loire* (Rive-de-Gier) being the most important in the world. In the second half of the century, the North (the department of North as well as neighbouring regions) became more important. England had an old tradition of glassmaking as well, nevertheless in 1840 Belgian imports to England exceeded England's own production. The United States had a rather limited window-glass production before 1880. In 1820, there were only 18 factories employing 20 to 40 workers each. By 1879, the number of factories rose to 49, employing approximatively 70 workers each. The United States remained one of the most important consumers of Belgian window glass until 1880 due to its strong demographic growth and ongoing westward expansion.[215]

The threat of foreign competition started to be more real from the mid-1860s onwards, as is attested by some records within the proceedings of the *Association des Maîtres de Verreries*, a business interest association uniting most of the Belgian window-glass manufacturers. In December 1866, during a discussion of new tariffs for the sales of Belgian glass on foreign markets, the important manufacturer Léopold de Dorlodot remarked that the proposed prices were too high, which could lead to the loss of various markets to the German, French and English manufacturers. Responding to de Dorlodot, Bennert, another prominent manufacturer, remarked that he saw the fear as unfounded, as German, French and English production had been insufficient to fill even their 'normal' markets. Moreover, according to Bennert, a reduction (*rabais*) could be applied to the price if necessary.[216] It can be remarked in this regard that England was in a paradoxical position, being a (potential) competitor as well as a consumer of Belgian glass at the same time, as will be shown further in this chapter. In general, the Belgian window-glass industry, as represented by the *Association*, maintained special ties with its English counterpart, represented by the *British [window glass] Manufacturers' Association* through the latter's representative George Gwilliam from approximately 1865 onwards.[217] Despite being competitors, Belgian and British glass manufacturers were coordinating their production and prices, as will be discussed further in the context of the international activities of the Belgian *Association* (Part 2, Chapter 2.2). In general, low prices appeared to have been the main Belgian advantage, as the English manufactures urged Belgians to increase their prices on the English market on many occasions throughout the years.

In 1868, the *Association* reported on the strong development of the window-glass industry in Saarbrücken and Westphalia, which had started to pose a serious threat to the Belgian industry in the German and Swiss markets.[218] This is an interesting observation, as it marks the rise of a (future) Germany as a new player on the international window-glass market alongside the older players such as France, England and Belgium itself.

Alongside the emergence of Germany as a new competitor, the 'traditional' competitor France started to strengthen its position in the international market as well from the 1870s onwards. According to the President of the Belgian *Association*, speaking in 1875, the French manufacturers formed a kind of 'restrictive arrangements' (*arrangements restrictifs*, most

[215] Mille, "Évolution de la branche verre plat," 60-87.
[216] Private archive Gobbe, Association, Originaux A, Séance 3 décembre 1866
[217] First instance in 1865: Private archive Gobbe, Association, Originaux A, Séance 19 septembre 1865
[218] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1868

probably a sort of cartel-like agreement) while retaining a commercial liberty of exports on the international markets. In this way, they could develop stronger competition with the Belgians as, according to the interpretation of the *Association's* president, they effectively made French customers carry the costs, while implicitly using the gains to expand on the international market.[219] The exact details of these 'arrangements' are unclear. Possibly, the situation was similar to that described in 1884, whereby German and French manufacturers could maintain high prices on their internal markets, while setting lower prices on international markets.[220] These examples illustrate, somewhat paradoxically, the importance of the internal market for the strengthening of a competitive position on the international market, an advantage that Belgium lacked due to its limited size.

In 1877, the *Association* addressed a letter to the Ministry of Foreign Affairs on the occasion of a new trade treaty with France. Therein, the *Association* stated that the French glass industry had come to dominate the market in London, which was then regarded as the most important in the whole world and had previously been dominated by Belgium. The letter, which was supported by all members of the *Association*, attributed this situation to an 'unfair' customs tariff, as well as to a number of other comparative advantages enjoyed by the French, that will be discussed in a paragraph at the end of this chapter. As for the tariffs, these had been established previously in 1875 as follows:

- 3.50 francs (not clear whether Belgian or French francs are meant) per 100 kg for the imports to France
- 10% ad valorum for the imports to Belgium

At the time of the previous treaty, these tariffs resulted in more or less equal amounts relative to the volume of the sales, yet by 1877, 3.50 francs for the import to France had become less in worth than the 10% for the opposite movement. If we are to believe the letter, to reach equity, the latter tariff should have been increased to 16%. Belgian manufacturers, as represented by the *Association*, required the Ministry to adjust the tariffs. The intention of the *Association* was not protectionist. On the contrary, by adjusting tariffs, the *Association* wished to be put on equal terms with their French competitors. In this way, tariffs would not provide an 'artificial' comparative advantage to any party, and so the free competition would be restored, at least according to the *Association*. It was due to the free competition that the industry could realise its greatest progress, as the *Association* wished to emphasise.[221]

Meanwhile, English manufacturers could impose competition on 'third markets' despite the 'special relationship' they maintained with the Belgian *Association*. For example, in 1879, Zunz (a trading agent) urged the Belgian manufacturers to lower prices for Canada, as this market had been threatened to be taken over by the English.[222]

The overall situation regarding exports is provided in a table from the Charleroi Chamber of Commerce Report of 1869 (Table 2).

[219] Private archive Gobbe, Association, Originaux C, Séance 28 août, 1875
[220] Private archive Gobbe, Association, Originaux C, Exposé de la situation par l'Ass-on des Maîtres de Verreries (undated, inscribed between the Assemblée Générale 26 mars 1884 and Assemblée Générale 31 mars 1884)
[221] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877
[222] Private archive Gobbe, Association, Originaux C, Séance 25 août 1879

Table 2: Exports of Belgian window glass (in kg), 1867-1969

	1867	1868	1869
Hanseatic cities	3,453,218	3,793,389	2,780,454
Netherlands	3,492,780	3,370,240	3,634,523
England	18,583,047	16,487,728	12,749,978
Turkey	2,164,393	2,445,245	2,862,124
United States	9,906,334	6,369,425	13,837,148
Egypt	590,104	492,315	193,127
Another	5,308,917	5,719,741	6,510,492
Total	44,700,368	38,678,083	41,366,271

Source: Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1869.* (Charleroi: n. p., 1869), 35.

The numbers make it clear that England and the United States were the main customers. Interestingly, the report mentioned that glass sold to England was used for English consumption almost entirely, with only a small portion being re-exported.[223]

The chaotic era: Disruptive innovation, tightening international competition and labour movement

Despite the first signs of rising international competition, as outlined above, the development of the Belgian window-glass industry proceeded in an almost linear way until the 1870s, save some occasional export crises. The production grew as more factories became established, mostly in the region of Charleroi.

The evolution of the total number of factories in Belgium for the 19th century is provided by several authors. For instance, the Tables 3 and 4 are based on the article by H. De Nimal (1904[224]) and the monograph Virgile Lefèbvre (1938[225]).

Table 3: Number of window-glass factories in Belgium, 1823-1876 (after De Nimal, 1904)

1823	1829	1833	1872	1876
10	23	32	42	46

Source: De Nimal, "L'industrie du verre à vitres en Belgique," 149.

[223] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1869.* (Charleroi: n. p., 1869), 35.
[224] De Nimal, "L'industrie du verre à vitres en Belgique," 149.
[225] Lefèbvre, *La verrerie à vitres*, 48.

Table 4: Evolution of the number of window-glass factories in Belgium, 1823-1886 (after Lefèbvre, 1938)

Year	Number of factories	Number of furnaces	Number of pots
1823	10	-	66
1834	21	37	224
1847	21	37	272
1874	54	207	1250
1875	59	-	-
1886	44	216	1300

Source: Lefèbvre, *La verrerie à vitres*, 48.

The comparison of these two tables presents similar general evolution, although some discrepancies are noticeable as well, most strikingly around 1833/1834 and, to lesser degree, around 1875/1876. Unfortunately, none of the authors did provide a detailed list of factories, listing the total numbers only, neither did any of them mention the exact source of numbers presented. The difficulties and challenges of the exact reconstruction of the population and number of factories will be discussed in more detail in the Chapter 1.5. These result from the difficulties of interpretation of sources (such as multiple factories belonging to one enterprise). Therefore, the data from the Tales 3 and 4 should be regarded as illustrative of general long-term trend rather than exact representation for each year mentioned. Further, the Chapter 1.5 will provide several lists of factories for several specific years (1836, 1880, 1907) based on contemporary sources rather than on later literature.

After 1880, however, the structure of the industry changed profoundly due to the introduction of the tank furnace. The total number of factories diminished from 46 in 1876 to 24 (of which 21 were located in the region of Charleroi) due to the fact that the introduction of tank furnaces required large investments that were beyond the capabilities of many smaller firms.[226] Moreover, apart from restructuring the window-glass industry in Belgium, the introduction of tank furnaces profoundly changed the position of Belgium on the international market as well, bringing an end to its dominant role.[227]

The technology of the tank furnace will be described in more detail further (Part 3, Chapter 3.3), yet it merits a brief discussion here, as it is necessary for the better understanding of the general evolution of the entire industry. Before the 1880s, a melting furnace contained several individual melting pots (crucibles). In them, the production of glass proceeded discontinuously, in a cycle starting with filling of the crucible with raw materials, the melting of the glass mass, and the 'gathering' of molten glass for blowing until the pot was empty. The tank principle, then, replaced individual pots with one huge tank, or a bath of molten glass. The process became continuous, as the raw materials were constantly refilled on one side of the tank while molten glass was 'gathered' for glassblowing on the other. The consequences of this innovation for labour were judged differently by various authors. Some

[226] Ibidem, 150.
[227] Poty and Delaet, *Charleroi pays verrier*, 67-68.

authors (Gita De Neckere, Poty and Delaet[228]) argue that the tank furnace caused de-skilling of glassblowers, which in turn led to social unrest. However, recent research by Widukind de Ridder concludes that the introduction of tank furnaces did not lead to the de-skilling of glassblowers.[229] In my opinion (see further elaboration in Part 3), there is no contradiction here. The old method required considerable skill on the part of workers, who had to assure the correct execution of all production steps from the initial melting of glass into every individual pot until the final 'gathering' of glass. Apart from the glassblowers themselves, the old method required other categories of skilled workers such as potters and furnace operators (known as *fondeurs*) who had to guide the process of glass melting.[230] It is difficult to judge whether the new method (continuous glass production) required less skill on the part of glassblowers themselves, yet the process as a whole underwent de-skilling, as the two categories of skilled workers, potters and *fondeurs* were eliminated.

Moreover, from the 1880s onwards, more countries could establish and rapidly extend their own window-glass industry. For instance, the American domestic glass industry developed quickly, causing Belgium to lose this market for the largest part. Germany rose to prominence as a producer of window glass as well in the second half of the 19th century. The majority of the German window-glass industry was situated within the Ruhr region. While the United States started to export window glass, other countries, such as Italy, Spain, Russia and Japan, started to produce window glass for their own domestic consumption, again limiting export opportunities for the Belgian industry.[231] This development is attested explicitly to the invention of the tank furnace in the contemporary account by G. Drèze who wrote on the state of the Belgian window-glass industry in 1911, and also in later research by Chrisitian Mille who studied the development of the window-glass industry in France. According to these authors, the tank furnace made the glass production less dependent on skills, so that countries with limited or even absent 'glass traditions' could establish their own glass industry more easily.[232] This supports the hypothesis that the tank furnace did indeed cause de-skilling, at least to some degree. Meanwhile, the 'traditional competitor' of France expanded at the expense of Belgium in the international market as well. In 1885, it was noted that French competition became tight on the Dutch market, while the Swiss market experienced growing German competition.[233]

The ascent of the American window-glass industry was particularly spectacular. For a long time, up to the last quarter of the 19th century, the glass industry (including window glass) of this country remained limited quantitively, and also lagged behind technologically. Although coal had first been introduced as a fuel for glass-melting in Pittsburgh in 1797, progress was slow, and by the mid-19th century most American glass factories still relied on firewood as the main fuel (although this can be attributed to the fact that the country possessed many forests, making firewood more accessible than in Europe). Moreover, it should be noted that, in itself, firewood often makes a better fuel than coal (see chapter on technology). Yet, the

[228] Gita Deneckere, *1900: België op het breukvlak van twee eeuwen* (Tielt: Lannoo, 2006), 68-72; Poty and Delaet, *Charleroi pays verrier*, 78-85.
[229] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 125-130.
[230] Ibidem, 96-97.
[231] Drèze, *Le livre d'or de l'exposition de Charleroi,* 464; Mille, "Évolution de la branche verre plat," 60-87
[232] Ibidem, p. 81
[233] Private archive Gobbe, Association, Brouillons II, Séance 20 novembre 1885

American industry lagged behind in other respects as well. The broad introduction of regenerative and tank furnaces in America took place about a decade later than in Europe, that is, not until the 1890s. For a long time, the annealers remained extremely primitive as well. An annealing tunnel (also known as 'lehr') was almost unknown in the United States before the 1880s (with the exception of a few factories), while in Belgium it had already been introduced in the late 1830s and 1840s and was much improved by the late 1860s (Biévez annealer, see Part 3, Chapter 3.3).[234] Quantitatively, by the early 1880s, the American window-glass industry could meet only 42% of domestic demand, while the rest had to be imported (to a large degree, from Belgium).[235]

Yet, the American window-glass industry developed rapidly from the 1880s and 1890s onwards, moving from a position of a 'lagging imitator' of the Europeans to a global leader regarding quantity of production as well as technology and innovation. Traditionally, the primary (but not the only one) centre of the American window-glass industry was located in Pittsburgh, yet from the 1890s onwards new production centres emerged in the 'gas belt' of southwestern Pennsylvania, Indiana and West Virginia (Clarksburg in particular) due to the switch to natural gas.[236] From the 1880s and 1890s onwards, American entrepreneurs developed an important advantage over the Europeans by employing natural gas as a fuel. From 1904 onwards, the American window-glass industry started to replace manual blowing by the mechanical Lubbers process, a development that contributed to the exclusion of Belgium from the American market.[237]

From approximately 1880 onwards, the situation of the Belgian window-glass industry became almost endemically precarious, as the sector entered a long period that included an overproduction crisis and a subsequent depression, as attested to by numerous remarks exchanged during the *Association's* meetings. For instance, severe difficulties due to overproduction had been mentioned in 1882, while in 1884, the general situation was described as critical.[238] In fact, a new type of crisis broke out in 1884-1885, partly caused by the situation in the United States. Therefore, we can even call it 'the American crisis', as the sources clearly indicate that the situation in the American market and the development of the American window-glass industry became one of the main challenges for the Belgian industry at that moment, as acknowledged by the *Association* itself. At the same time, it was on this occasion that the labourers started to act as a single organised actor for the first time.[239]

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[234] Warren C. Scoville, "Growth of the American Glass Industry to 1880," *Journal of Political Economy* 52, no. 3 (Sept. 1944): 193-216.

[235] Ken Fones-Wolf, "Transatlantic Craft Migrations and Transnational Spaces: Belgian Window Glass Workers in America, 1880-1920," *Labor History* 45, no. 3 (Aug. 2004): 299-321.

[236] Scoville, "Growth of the American Glass Industry to 1880," 193-216; Fones-Wolf, "Transatlantic Craft Migrations and Transnational Spaces," 299-321; Ad Knotter, "Trade unions and workplace organization: regulating labour markets in the Belgian and American flat glass industry and in the Amsterdam diamond industry in the nineteenth and early twentieth centuries," *Labor History*, 57:3 (2016): 415-425.

[237] Cable, "The Development of Flat Glass Manufacturing Process," 25-27.

[238] Private archive Gobbe, Association, Originaux C, Séance 29 décembre 1882; Brouillons II, Séance 6 février 1884

[239] Private archive Gobbe, Association, Brouillons II, Assemblée Générale 6 février 1884; Brouillons II, Séance 16 février 1884, Séance 23 février 1884

As attested to by the *Association* itself, the year 1884 had nevertheless started in 'brilliant conditions', largely due to the strikes in the American window-glass industry that had allowed the Belgian industry to reach its 'maximum intensity'. Yet, on 1 February that year, an agreement was reached between manufacturers and workers in the United States, resulting in the resumption of work there and, subsequently, a 20% fall in prices. Suddenly, the Belgian industry went from a period of prosperity to one of severe crisis, literally overnight. The manufacturers strove for the lowering of glassblowers' wages in order to decrease the overall cost price. Yet this intention met with resistance on the part of the glassblowers' labour union, *Union Verrière*. The conflict largely revolved around the so-called 'two-for-one' working arrangement, which had been supported by the *Union Verrière*, but was opposed by the *Association* (more on this see Part 2, Chapter 2.2).[240]

In fact, starting with the 'American crisis', the conflicts between the manufacturers and the labourers' (mostly glassblowers) *Union Verrière* (and, later on, *Nouvelle Union Verrière*) became almost permanent during this period. The first glassblowers' labour union, *Union Verrière*, was established in 1883. Events reached crisis point between 18 and 29 March 1886, when the industrial region of Wallonia known as the 'Black country' (*Pays Noir*, the regions of Liège and Charleroi) experienced violent strikes, known as the 'Social Revolt', which had to be suppressed by the Belgian Army. While the strikes were not limited to one particular industry, many glass factories were targeted. Strikers even burnt down the entire factory of Eugène Baudoux, who was the first to introduce tank furnaces, as well as his own mansion.[241]

These violent events clearly showed the increasing role of the labour movement. After the events of 1886, the *Union Verrière* was abolished by the authorities, while the two most well-known union leaders, Oscar Falleur and Xavier Schmidt, were put on trial as instigators of violence. Yet, after various attempts, the glassblowers' union was re-established as the *Nouvelle Union Verrière* in 1894. It should be noted that both the *Union Verrière* and the *Nouvelle Union Verrière* united the 'hot glass workers' (glassblowers and their assistants, known as *gamins*) only, while the 'cold glass workers' (glass cutters and others) had their own union [242] By that time, the introduction of tank furnaces had engendered a new crisis within the industry, making it a victim of its own success. As attested to by a report drawn up by the *Association* in 1899, this modernisation caused an imbalance between the production capacity and demand, that became quite apparent by 1896. As the overproduction caused prices to decline, the employers reacted by cutting workers' wages, while glassblowers resisted by refusing to work in certain factories and by strengthening their labour union. As a reaction, the employers started to strengthen their own organisation as well. This crisis resulted in the bankruptcy of two major firms, together encompassing approximately 15% of the total production capacity. Due to these bankruptcies and the resulting decrease of

[240] Private archive Gobbe, Association, Originaux C, Assemblée Générale 27 juillet 1885 – Rapport sur la situation en 1884

[241] Poty and Delaet, *Charleroi pays verrier* 78-98; Knotter, "Trade unions and workplace organization," 422-424; Geneckere, *1900: België op het breukvlak van twee eeuwen*, 68-71.

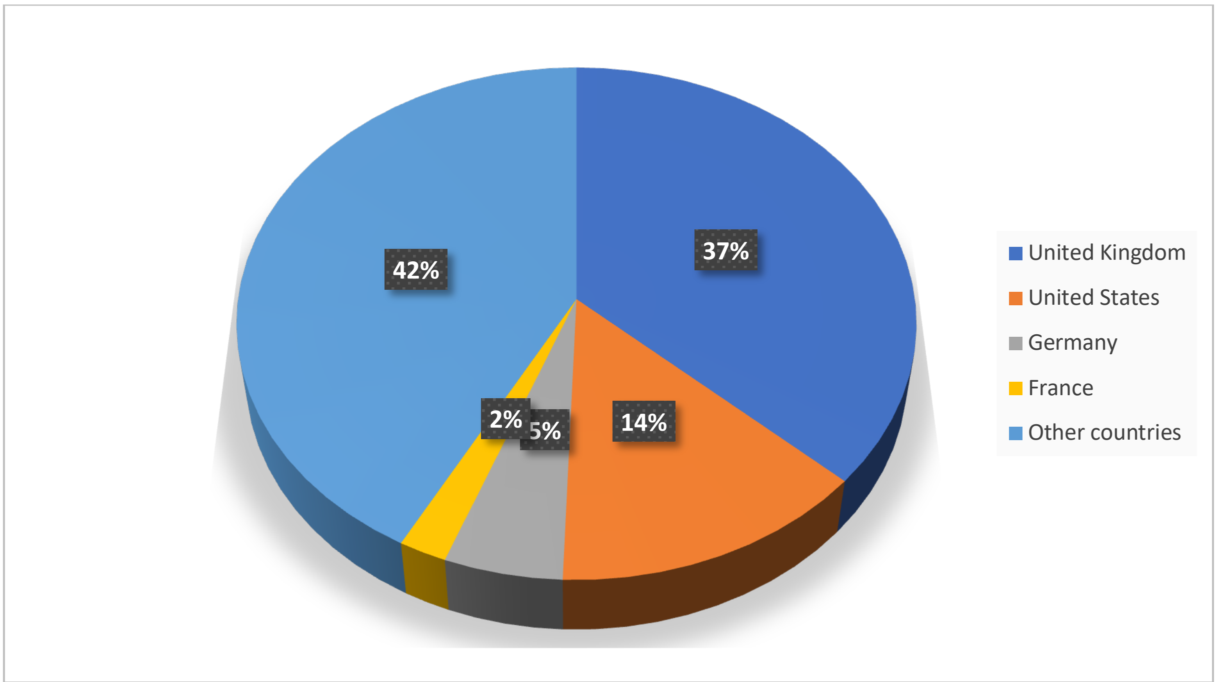
[242] Poty and Delaet, *Charleroi pays verrier* 78-98; Knotter, "Trade unions and workplace organization," 422-424; Geneckere, *1900: België op het breukvlak van twee eeuwen*, 68-71.

production capacity, the market situation did stabilise somewhat while the workers became more 'docile', as the report put it.[243]

The tank furnace can be described a truly disruptive innovation, as it caused a far-reaching reorganisation of the entire industry, considering both the international position (ascent of new competitors on the global market) as well as the labour relationships within Belgium. As for the markets, the 1899 report provides some quantitative data (see Graph 1). The total volume of exports amounted to 152,948,000 kg in 1898 (up from 77,860,000 in 1878). Germany was regarded as an important market, receiving 7,917,000 kg in 1898 (up from 5,679,000 in 1879), not including exports to Hamburg, which were mostly re-exported to the Far East. France was an important market as well. In 1898, it received 3,229,000 kg (for 1891, exports to France amounted to 2,963,700 kg, and declined after the introduction of a new tariff in 1892, but rallied afterwards). The United States still absorbed 21,232,000 kg of Belgian glass in 1898 despite the rapid development of its own domestic industry as well as high tariffs implied by the protectionist Dungley bill. The most important customer was the United Kingdom, which imported 56,138,556 kg of Belgian window glass in 1898. The majority of these exports were actually re-exported further to the British colonies. Interestingly, the *Association* regarded this situation as advantageous, as it allowed the Belgian industry to access new markets thanks to the British infrastructure of 'transport equipment and financial infrastructure that has ramifications throughout the whole universe'.[244] Last but not least, China is mentioned. Although no numbers are provided, this country is mentioned as an important emerging market as this immense empire opened up to 'European commerce and Western civilisation'. It was hoped that the emerging Chinese market would compensate for the decreasing American one.

[243] Private archive Frédéric Gobbe, Association, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1896-97-98 (inscribed between the proceedings of 6 March 1899 and 21 April 1899)
[244] Private archive Frédéric Gobbe, Association, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1896-97-98. Original quote: "par son matériel de transport et son outillage financier ayant ses ramifications dans l'univers entier"

Graph 1: Export of Belgian window glass in 1898 (by weight), according to a report by the Association des Maîtres de Verreries



Private archive Frédéric Gobbe (Charleroi), Association des Maîtres de Verreries, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1896-97-98

As for the threats, the 1899 report pointed explicitly to the social laws that started to be implemented at that time. In particular, the law on the prohibition of night work for women and children was regarded as unacceptable, as the *Association* demanded permission to employ children of 12 years old and younger during night hours.[245] This must have been a reaction to the first Belgian law on child labour (1889) that forbade industrial labour for children under 12 and night labour for children between 12 and 16, even though the glass factories were granted an exemption, allowing night work for children starting from 14 years old.[246] Moreover, the *Association* presented itself as a champion of free trade, requiring the suppression of all custom tariffs as well as the lowering of transport tariffs.[247]

In 1900, a severe crisis broke out due to the conflict between the *Nouvelle Union Verrière* and the employers. The union had two main demands, the employment of workers by collective contract and a system of 'sharing' work between labourers (known as 'travail à deux pour un', labour of one for two) during periods of partial inactivity of factories known as *chômage* in order to avoid layoffs. After the refusal of the employers, a general strike within the window-glass industry broke out in July 1900. From 1 August on, work ceased completely at 21 tank furnaces, as 7,336 workers went on strike. Nevertheless, ten tank furnaces

[245] Private archive Frédéric Gobbe, Association, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1896-97-98

[246] Deneckere, *1900 België op het breukvlak van twee eeuwen*, 68-75, 129-130; "La législation protectrice en Belgique," in *Le musée social. Inauguration 25 mars 1895* (Paris: Musée social, 1895), 432-433.

[247] Private archive Frédéric Gobbe (Charleroi), Association des maîtres de verreries, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1896-97-98

remained active as they were manned by workers who were not members of the union, or by apprentices who had long-term contracts and could not quit work.

In February and May 1901, the owners of two factories in Courcelles and Gilly near Charleroi wanted to accede to the union's demands but were overruled by the *Association des Maîtres de Verreries*. In order to resist the strikers, the *Association* had set up a fund known as *La Mutualité des Verriers Belges* that was intended to unite employers in the face of strikers. The strike ended on 21 May 1901 when the union had to admit defeat. Nevertheless, normal work could only start again on 15 June, as the ignition of a tank furnace took three weeks.

This strike of almost eleven months had a profound effect on the position of the Belgian window-glass industry on the global market, as foreign competitors were eager to seize vacant markets. In France the total production of window glass tripled during this period, while in England, the Pilkington Brothers, the largest glass factory in the world, had built four or five new furnaces. As noted above, the United States and Germany became prominent exporters of window glass, while countries such as Italy, Russia, Spain, Sweden and Romania had started to produce window glass as well. Consequently, Belgian exports diminished. At the same time, prices on the global market started to decrease, worsening the crisis even further.[248]

The situation directly after the strike of 1901-1902 is described in a report drawn up by the *Association* in 1903. The total value of yearly exports (unlike the report of 1899, expressed in Belgian francs rather than in tons, see Table 4) amounted to 46,135,290 in 1899, 37,825,117 in 1900, 37,900,967 for 1901 and 50,624,738 for 1902, making clear both the decline in exports due to the strike as well as the rapid recovery afterwards. As for the specific markets, the report mentions that the United Kingdom accounted for 30% in 1902 (a total value of 16,279,003 Belgian francs), without it being clear which part was re-exported to the British colonies (moreover, the British Indies are regarded as a separate category). The United States still consumed 14% of the Belgian export (curiously, the absolute amount is not mentioned).

The report also specified that Japan, China, the British Indies and Turkey were growth markets, with export figures for 1900, 1901 and 1903 (Table 5):

Table 5: Export of Belgian window glass to the growth markets in 1900-1901-1903, according to a report by the Association des Maîtres de Verreries (in Belgian francs)

	1900	1901	1903
Japan	1,633,705	2,462,475	3,119,273
China	1,200,826	1,556,707	2,804,704
British Indies	1,052,320	1,271,362	1,545,469
Turkey	981,664	767,939	1,684,119

Source: Private archive Frédéric Gobbe, Association, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1900-1901-1902

248 Misonne, "La crise verrière dans le bassin de Charleroi," 67-71; De Nimal, "L'industrie du verre à vitres en Belgique," 154-155; Poty and Delaet, *Charleroi pays verrier*, 99-103; Private archive Frédéric Gobbe, Association, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1900-1901-1902

Japan in particular was regarded as a promising market. Referring to an American source (report of the National Glass Budget of Pittsburgh of 20 December 1902), the 1903 report mentioned that Belgium basically monopolised the Japanese market of window and mirror glass, as the total value of Belgian imports amounted to one million yen, while the British imports amounted to only 35 thousand yen, German to 13 thousand yen, and American to five thousand yen. This example illustrates the ability of Belgium to conquer new markets, although the exact whereabouts of this conquest, including the role of diplomatic ties and foreign intermediaries, is beyond the scope of the present study. Moreover, the *Association* was determined to keep a close eye on Japan in the future, as this nation 'was making great leaps on its way towards civilisation.'[249]

In general, the British Indies and the Far East were regarded as promising markets, mainly due to the low price (which was, implicitly, regarded as the main advantage, see paragraph on comparative advantages below). On the other hand, exports to Switzerland, Germany, Egypt, Romania, Russia, Spain, France, Sweden and Norway were in decline. The report mentioned explicitly that foreign competitors could expand their influence in the aftermath of the Belgian strikes. In particular, France further expanded its existing industry, while Italy entered the international market in the Mediterranean region, Turkey and the 'pays Danubiens' (Danube countries, thus Austria-Hungary). The low production cost was regarded as the most important advantage of Belgian firms.[250]

For a long time, low production prices remained the major, comparative advantage of the Belgian window-glass industry on the global market (see paragraph on comparative advantage further). Yet the situation started to change after 1900, adding to the overall feeling of crisis. For instance, speaking in February 1904, Fourcault remarked that the bad situation within the Belgian window-glass industry had been caused by high prices exclusively. According to him, the diminishing of sales of Belgian glass in England between 1902 and 1903 had been caused exclusively by the rise in cost and not by the fall in consumption, as Pilkington had commissioned four new tank furnaces during the same period, 'conquering' a market share at the expense of Belgium.[251]

Nevertheless, the relationships between employers and workers normalised after 1909, due to an agreement between the *Association des Maîtres* and the *Nouvelle Union Verrière*, represented by a prominent union leader Edmond Gilles. This agreement, known as *l'entente cordiale*, held out until the First World War.[252] Other social issues started to appear from the 1890s and, more prominently, from the 1900s onwards in the form of emerging social legislation that concerned child labour in particular. The *Association* regarded these laws as

[249] Private archive Frédéric Gobbe, Association des maîtres de verreries, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1900-1901-1902. Original quote: "Il est donc de plus grand intérêt de suivre attentivement les développements de ce peuple qui marche à pas énorme dans la voie de la civilisation"
[250] Private archive Frédéric Gobbe, Association des maîtres de verreries, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1900-1901-1902
[251] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 8 février 1904
[252] Poty and Delaet, *Charleroi pays verrier*, 108-111.

most 'dangerous to the industry', as it assumed that in order to train a skilled workforce, apprenticeship of the work had to begin early.[253]

The situation between the strikes of 1901 and of 1914 can be described as perilous in general. The overcapacity of production equipment became endemic. For example, in 1908, of the 43 tank furnaces in existence in Belgium, only 15 were active, while 27 were out of service and two 'served at the relay' ('servaient au relais', meaning probably that they were held in reserve).[254] Writing in 1909, Georges De Leener, an economist at the University of Brussels, described the situation of the Belgian window-glass industry as being affected by a long-term depression due to the semi-permanent overproduction[255]

The irregular nature of exports during this period can be illustrated with data from a contemporary article by A. Lalière (professor at the Higher Commercial Institute of Antwerp (one of the predecessors of the present-day University of Antwerp [256])[257]. As can be seen from the Table 6 below, exports not only regained their pre-strike levels, but effectively reached new heights, peaking in 1912. Nevertheless, the comfortable semi-monopolistic position of uncontested global market leader was lost.

Table 6: Exports of Belgian window glass in the early 20th century

Yearly exports (selection)		
Years	Exports (thousand ton, approx.)	Remarks
1900	126	
1901	126	
1903	170	
1904	129	New strike
1906	212	
1908	155	
1912	217	Highest exports ever

Source: Lalière, "Le verre en Belgique," 615-616.

The situation of the Belgian window-glass industry in 1912 is worth discussion for various reasons. Alongside being a top year, when total production and exports are considered, it was a year at the threshold of profound transformations caused by the First World War and technological innovations (mechanical production of glass).

[253] Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913 (inscribed between Assemblée Générale du 9 février 1914 and Assemblée Générale du 18 décembre 1914)
[254] De Leener, *L'Organisation syndicale des chefs d'industrie,* vol. 1 les faits, 227-228.
[255] Georges De Leener, *L'organisation syndicale des chefs d'industrie*, Vol. 2, *La théorie* (Brussels and Leipzig: Misch & Thron, 1909), 54, 60.
[256] A. Lalière, "Les industries du verre," in *Études sur la Belgique* (Brussels, Leipzig and Paris: Misch et Thron and Marcel Rivière et Cie, 1913), III. 6, 1.
[257] Lalière, "Le verre en Belgique," 615-616.

Meanwhile, the structure of the exports changed significantly after 1900, as compared to the situation in the last decades of the 19th century, as represented in the Table 7 and Graph 2 here (source: Lalière[258]).

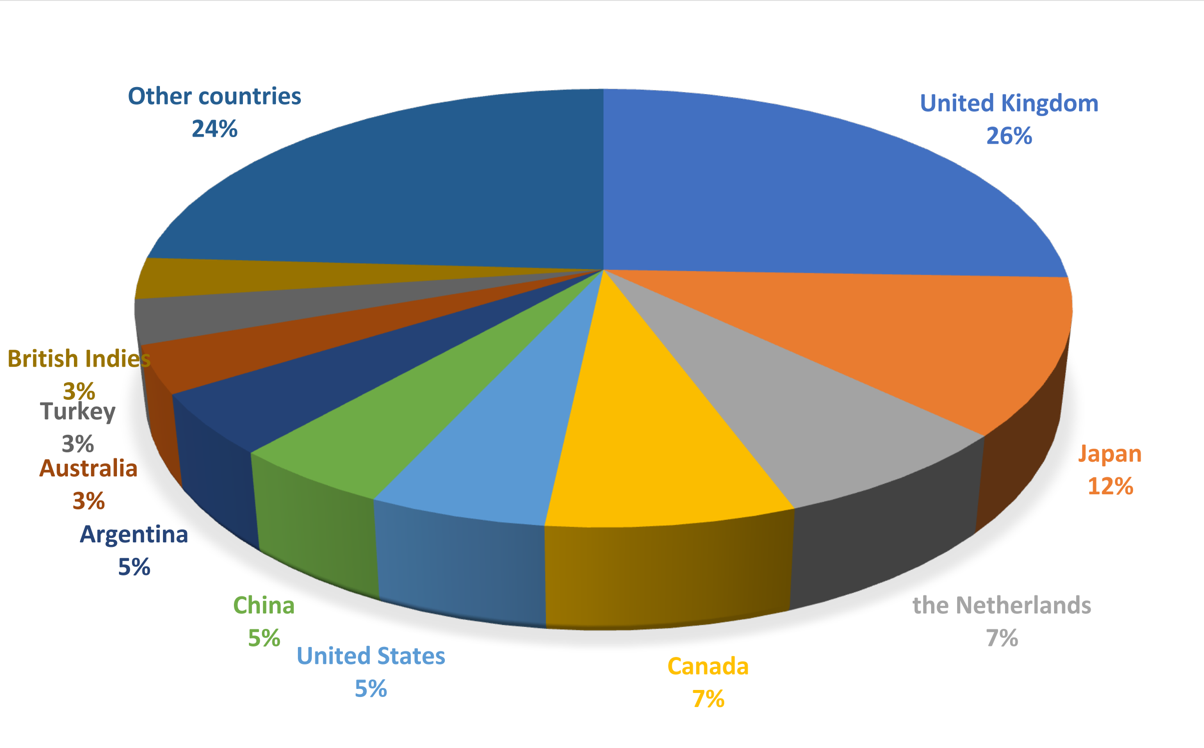
Table 7: Destinations of the exports of Belgian window glass for the period from 1907 to 1911 (in Belgian francs)

Destination	Value
United Kingdom	8,756,577
Japan	3,944,011
Netherlands	2,500,671
Canada	2,499,650
United States	1,778,309
China	1,599,389
Argentina	1,549,018
Australia	1,197,714
Turkey	1,119,385
British Indies	1,049,667
Other countries	8,255,289

Source: Lalière, "Les industries du verre," III. 6. 19.

[258] Lalière, "Les industries du verre," III. 6. 19.

Graph 2: Destinations of the exports of Belgian window glass for the period from 1907 to 1911 (by money value)



Source: Lalière, "Les industries du verre," III. 6. 19.

As is evident from the diagram, the United Kingdom remained the main outlet for Belgian exports despite having its own window-glass industry. As noted already, a large part of Belgian exports to the United Kingdom were re-exported towards various British colonies. The United States present an interesting case as well. Around 1885, the United States was the main outlet for Belgian exports alongside the United Kingdom. Due to the development of the domestic American industry alongside the prohibitively high import duties (up to 100% ad valorum), Belgian exports to the USA decreased dramatically. Nevertheless, Belgium retained a small yet important market share due to the high quality of Belgian glass. In particular, Belgium possessed a quasi-monopoly position concerning extra-thin glass, such as that used for photograph panes.

The markets of Germany, Spain, Russia and France were effectively closed to Belgian imports due to 'tariff walls' of import duties. On the other hand, Belgian exports were increasing towards China and Japan, the *Pays Danubiens* (the exact meaning of this term is unclear, as, it could presumably designate Austria-Hungary or Romania, historically known as the Danubian principalities), Mediterranean countries and South America. While Belgian companies had been able to maintain or even increase their presence on the market of countries without their own domestic window-glass production, the situation was rather difficult for the countries with their own domestic production.[259] Moreover, as noted above, by the early 20th century more and more countries started to develop their own window-glass industry. For instance, in 1909, the *Association* acknowledged that the Austrian

[259] Lalière, "Les industries du verre," III. 6, p. 17-21.

window-glass industry was developing at a rapid pace at that moment, increasing exports to the *Pays Danubiens*.[260]

The prospects of the Belgian window-glass industry on the eve of the First World War were represented differently in various sources. For instance, the *Association* described the 'economic horizon' as 'dark' due to external (international competition, customs tariffs) as well as internal (social legislation) difficulties in its 1913 report. According to this report, the struggle to maintain its position on the international market was getting ever harder due to the tightening competition. And yet the same report mentioned that, despite all difficulties, the total number of exports reached its top in 1912, as some 'lost' markets were compensated by 'new' ones. In particular, the *Association* regarded the Balkan countries (which were recovering from 'recent troubles', that is, Balkan wars) and Latin America, were regarded as promising markets.[261] An article on the state of the Belgian glass industry by Lalière, published in the same year, presented a much less gloomy picture. While difficulties in foreign markets were acknowledged, the general tone was modesty optimistic rather than alarmist. Lalière even wrote that the window-glass industry could finally regain the stability that had been missing for the previous twenty years. Curiously, Lalière attributed this stability to the actions of both the *Association* and the *Nouvelle Union Verrière*, which succeeded in negotiating the interests of capital and labour.[262] Possibly, the alarmist tone of the *Association* was a (part of) rhetorical strategy.

The last development worth noting is the development of the mechanical production method by Émile Fourcault, which replaced manual glassblowing. In this process, an endless strip of glass was mechanically drawn from a bath of molten glass mass by means of a 'bait' called *débiteuse*. A *débiteuse* resembled a 'boat' made of refractory material and having a central slit, which was gently forced into the glass mass. As the glass poured through the slit, it was gripped and pulled upwards by special rollers. Although Fourcault established one factory for mechanical glass production in Dampremy (experimental production in 1906, normal production in 1912), large-scale mechanical glass production was only introduced after the First World War, and is therefore not relevant here. It should be kept in mind, however, that the First World war signified a fundamental milestone for the Belgian window-glass industry for more than just political reasons.[263]

Hence, the period between 1830 and 1914 saw significant changes in the international position of the Belgian window-glass industry, from the almost linear growth and dominant positions between 1830 and ca 1880 and a much more irregular period between 1880 and 1914 during which the international competition strengthened. Despite this, the total production of window glass in Belgium still grew during this later period, albeit prone to many periodic crises. Unfortunately, the exact relative position of the Belgian window-glass industry on the global market (market share) is difficult to assess due to the lack of quantitative data on production numbers for various countries. For example, no numbers were provided in Christian Mille's study of the flat glass industry in France and Europe.

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[260] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 18 juin 1909

[261] Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913

[262] Lalière, "Le verre en Belgique," 625-627.

[263] Cable, "The Development of Flat Glass Manufacturing Process," 27; Thomas, "La société anonyme Brevets Fourcault," 224-229.

Nevertheless, he mentioned that the number of window-glass factories dropped from 54 in 1874 to 21 in 1899 in Belgium (due to the introduction of the tank furnace) and from 17 in 1880 to 10 in 1910 in Northern France. This provides a very rough indication of the position of Belgium relative to one of its main competitors.[264] Mille did not mentione how many factories existed in other parts of France, but he mentioned that the majority of the French window-glass industry was concentrated in that region by the late 19th century.[265] Leen Lauriks et al. mentioned that in 1906, Belgium produced 1/5th of the European, and 1/6th of the world's glass. This claim was based on a quote from Raymond Chambon.[266]

Belgian investments in foreign countries

One aspect that is worth mentioning within the context of the Belgian presence on the global market is Belgian foreign investments. From the late 19th century until at least the First World War, Belgium had been renowned for its active foreign investment policy. The sectors included tramways and railways, coal mines, metallurgy and chemicals, while the geography of investments encompassed many European countries, South America, China and Russia.[267] The window-glass industry, on the other hand, remained largely reluctant about investment in foreign countries. In fact, even the possibility of such investments was regarded as undesirable, as illustrated by a case recorded in 1892. In that year, a proposition for the establishment of a glass factory in Italy with Belgian capital was made by the Belgian delegation in Rome. However, the *Association* was not in favour of the idea, as it did not wish to support foreign competition. Apparently, even a potential Belgian-financed foreign enterprise was regarded as such. Instead, the *Association* wished to renew its demands for the adjustments of transport tariffs.[268]

Despite this reluctance, a few cases of Belgian investment in the window-glass industry in foreign countries were recorded. Two of them, a successful one (Russia) and an unsuccessful one (Japan), can be compared in order to understand better what kind of difficulties could arise in the course of technology transfer (including, in a broad sense, knowledge and know-how, as well as managerial practices). Indirectly, these cases illustrate the advantages of the well-established environments for the further development of industry, as had been the case in the Charleroi region.

Despite some earlier precedents, it can be stated that the industrial revolution in Russia started with the Great Reforms of Alexander II, beginning with the abolition of serfdom in 1861. Although the age of political reforms came to an end in 1881, the industrial development continued. Moreover, foreign investors, including Belgians, had played a key role in this process.[269] The industrial region of Donbass in present-day Ukraine in particular

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[264] Mille, "Évolution de la branche verre plat," 81-84.
[265] Ibidem, p. 62-63
[266] Leen Lauriks et al., "Technical improvements in 19th-century Belgian window glass production." Integrated Approaches to the Study of Historical Glass. Vol. 8422. SPIE, 2012.
[267] Ginette Kurgan-Van Hentenryk, "Industriële ontwikkeling," In Vol. 13 of *Algemene geschiedenis der Nederlanden*, ed. Dick Peter Blok (Haarlem: Fibula-Van Dishoeck, 1977-1983), 21-24.
[268] Private archive Gobbe, Association, Brouillons III, Séance 5 février 1892
[269] Peter N. Stearns, *The Industrial Revolution in World History* (Boulder, Colorado: Westview Press, 2007), 123-141.

had attracted many Belgian investments which were directed towards metallurgy, chemicals and other sectors.[270]

The most important Belgian window-glass enterprise in Russia of that time was the *Verreries du Donetz, à Santourinowka* (present-day Konstantynivka in Donbass, Ukraine). It was established 'on paper' in Brussels on 14 September 1895 with capital of 5,000.000 Belgian francs. The *Verreries de Mariemont* and the *Verreries de Hamendes* were the main investors. The window-glass and bottle factory in Santourinowka was built in 1896-1898. The factory proved to be quite successful, delivering finished products to customers throughout Russia, including Moscow and Saint Petersburg. The quality of these products, 'generic' window glass as well as various special types of glass, was acknowledged by the golden medals awarded by juries at eight national Russian expositions. Moreover, the *Verreries du Donetz* provided materials for the 'summer retreat' palace of the Russian tsar in Livadiya (Crimea). Alongside local workers, the factory employed Belgian engineers, executives and labourers from the region of Charleroi. After the Russian revolution, the factory was nationalised and thus lost to the Belgian owners.[271]

As mentioned above, Japan had been recognised as a promising market in the early 20th century. Guided by the slogan bunmei-kaika (文明開化, (possible translations include 'civilisation', 'modernisation' or 'enlightenment'), first coined by the passionate reform advocate Fukuzawa Yukichi, the country had been pursuing an active policy of industrial development and technology transfer after the Meiji Restoration of 1868, in order to introduce all the modern technologies of the Western world.[272] Foreign entrepreneurs and engineers, known as o-yatoi gaikokujin (御雇い外国人, 'hired foreigners') were welcomed by the Japanese government as well as by the private sector on generous terms in order to assist the process.[273] Moreover, the introduction of Western-style architecture, such as public buildings as well as private homes, obviously created a demand for window glass.[274] Hence, the opportunities looked promising.

The *Verreries d'Extrême-Orient* were founded in February 1907 under the conditions of Japanese law. The initial capital amounted to 3,800.000 Belgian francs, the main investors being the *Cristalleries du Val Saint-Lambert*, the *Société des Glaces et Verres Spéciaux du Nord*, the *Compagnie d'Orient* and the *Banque d'Outremer*. The main purpose of the firm was to produce window glass by the Fourcault method, with auxiliary production of bottles and goblets. However, the whole plan failed almost immediately, as the Fourcault method

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270 Kurgan-Van Hentenryk, "Industriële ontwikkeling," 21-24.

271 Darquennes and Gobbe, *Les verriers Schmidt*, 61-66; John P. McKay, *Pioneers for Profit. Foreign Entrepreneurship and Russian Industrialization, 1885-1913* (Chicago: University of Chicago Press, 1970), 51; Andrii Mykhailovych Novoselskyi, *Sklo Donechchyny: istoriia sklianogo vyrobnytstva Kostiantynivky* (Zhytomyr: Yevenok, 2020); Andrii Mykhailovych Novoselskyi, "Budivnytstvo, orhanizatsiia i tekhnolohii sklianoho zavodu v Kostiantynivtsi naprykintsi XIX-pochatku XX stolittia," In *Slobozhanshchyna. Pohliad u mynule* (Zhytomyr: Yevenok, 2020), 194-204.

272 Dallas Finn, *Meiji Revisited. The Sites of Victorian Japan* (New York and Tokyo: Weatherhill, 1995), 118-157; Teijiro Muramatsu, *Industrial technology in Japan: a historical review* (Tokyo: Hitachi, 1968); Stearns, *The Industrial Revolution in World History*, 143-163.

273 Neil Pedlar, *The Imported Pioneers. Westerners who helped build modern Japan*. (Sandgate, Folkestone, Kent: Japan Library, 1990)

274 Finn, *Meiji Revisited*, 93-117, 157-253.

was still at the experimental stage and the firm was not successful in applying it in a practical setting. In order to save the situation, the firm issued a mortgage loan of 1,300,000 francs to adapt the factory to the old method of production of window glass as well as bottles by manual blowing. Twenty or thirty Belgian glassblowers were sent to Japan when, suddenly, the firm changed policy. All contracts were broken, and the construction of a tank furnace was halted. On 1 October 1908, all European personnel were sent back, and the directorship was handed over to the Japanese. After this, the case was basically lost. Finally, attempts were made to produce bottles with machines, but the gains were insufficient in comparison to the invested capital. In April 1909, all production ceased, and on 5 November 1909 the firm was liquidated.

The contemporary press attributed the failure of the *Verreries d'Extrême-Orient* to bad management, as the challenges had been taken up 'too lightly' (*administrée avec une incroyable légèreté*). Moreover, the whole structure of governance was inadequate, as the company seat was located in Tokyo, the production facilities in Osaka, the board of directors in Jeumont (France) and accounting in Brussels, complicating the co-ordination between various departments.[275]

The comparison with the successful Russian case brings more systematic factors to the fore. While Belgian investors had already been firmly established in Russia at the time, any examples of Belgian investments in Japan were quasi absent.[276] Establishing a new business in a foreign country without pre-existing networks is not without risk. Moreover, the choice to use the promising, yet still experimental technology of mechanical production proved to be an unlucky one. In Russia, the manual method remained in use until 1917.[277] While already obsolete, this method proved to be successful on the Russian market, arguably due to the imported Belgian know-how.

Emigration from Belgium and spread of know-how

Direct Belgian investments were not the only means of the worldwide dissemination of Belgian know-how. The emigration of skilled workers (glassblowers) helped considerably in this respect as well. Already in 1850, the *Association* acknowledged the problem of glassblowers emigrating to 'neighbouring countries' (presumably England and France), proposing the vocational training of new glassblowers as a solution.[278] This is the earliest mention of emigration of glassblowers from Belgium, and must have been significant enough to raise the glassmasters' concern. The existing literature situates the onset of mass migration a few decades later, from approximately the 1880s through to the early 20th century, attributing it to the consequences of the social conflicts of that time.[279] On the other

[275] *Moniteur industriel*, 26 mars 1910, Nr 13.
[276] For instance, a recent edited volume on Belgian-Japanese relationships does not mention any Belgian industrial activities for this period, Willy Vande Walle, ed. *Japan & Belgium. An Itinerary of Mutual Inspiration* (Tielt: Lannoo, 2016)
[277] Novoselskyi, "Budivnytstvo, orhanizatsiia i tekhnolohii," 194-204.
[278] Private archive Gobbe, Association, Originaux A, Séance 8 août 1850
[279] Poty and Delaet, *Charleroi pays verrier*, 76-78, 108; Knotter, "Trade unions and workplace organization," 423.

hand, the *Association's* proceedings of 1850 do not provide any quantitative data on the number of departed workers.

Skilled Belgian glassblowers started to emigrate to the United States (mainly Pittsburgh) in the 1880s. Ironically, they played an important role in the development of the American window-glass industry, which was to become the main competitor of Belgium on the global market by the early 20th century. The migration was stimulated by the semi-permanent state of overproduction and overcapacity in Belgium, while the American labour market was eager to welcome a new skilled workforce from Europe in general and Belgium in particular. In America, the wages of glassworkers were more than double when compared to Belgium. Every time the economic conditions worsened, emigration intensified.[280] As attested by a local newspaper in September 1907 (quoted by Poty and Delaet), large numbers (no exact numbers provided) of specialised workers emigrated towards Russia of that time (Santourinowka), Italy (Milan and Resina (present-day Ercolano)), Spain (Gijón and Avilés) and Switzerland (Zürich). In 1908, emigration to Russia and Japan were reported.[281]

Types of business organisations within the window-glass industry and the demand for capital

Alongside quantitative growth and technological advances, the Belgian window-glass industry experienced changes to its business organisation in the course of the 19th century. In this context, 'business organisation' stands for the type of legal entity of the production units and should not be confused with business interest organisations that united various enterprises, such as chambers of commerce (they will be discussed later in Part 2, Chapter 2.2).

The Encyclopaedia Britannica defines a business organisation as 'an entity formed for the purpose of carrying on commercial enterprise' and makes a further broad distinction between individual proprietorships, partnerships and limited liability companies (or corporations). While strictly applying the present-day legal definitions to the 19th-century context would be rather anachronistic, this basic distinction into three types appears as a useful tool for the analysis. Hence, in the case of individual proprietorship, a single person owns the entire company as their personal property. Then, in the case of partnership, the enterprise is owned by several members (partners). Lastly, in the case of a limited liability company, the enterprise is a legal body, separated from its shareholders and recognised by a public authority.[282]

In the early 19th century, individual proprietorship and partnership were the two most common types of business organisation in the Belgian window-glass industry. Indeed, as discussed in more detail in Part 1, Chapter 1.4, family enterprise (quite often, multigenerational) was very typical for this industry. The situation for the first decades of the

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[280] Poty and Delaet, *Charleroi pays verrier*, 76-78, 108; A. Knotter, "Trade unions and workplace organization," 420-421.

[281] F. Poty and J.-L. Delaet, *Charleroi pays verrier*, p. 108

[282] Nicholas S. Woodward ,"Business organization," Encyclopedia Britannica, published 09 November 2022, accessed 01 April 2023. https://www.britannica.com/topic/business-organization

19th century can be assessed using the requests for the establishment of factories (*Administration des Mines*), as they mention the name(s) of the applicant(s). In most cases, one name was mentioned, implying individual proprietorship. Yet partnerships, while much less frequent, were certainly present as well. It should be noted that in some (but not all) cases partners had the same surname, implying kin ties. Hence, no clear-cut distinction between individual proprietorship and partnership can be drawn, as the 'family partnership' (partnership between family members) could be regarded as a kind of intermediate organisation form.

Providing any quantitative analysis of the business organisation based on the requests from the *Administration des Mines* is not straightforward either, as a single factory could be subject to multiple requests (for the establishment, 'keeping in operation' and expansion), issued to different persons, in the course of its history. For instance, one file could contain a request for the establishment of a new factory, a request for the 'keeping in operation' of the same factory a decade later (it is not clear why such a request was required), and a request for expansion (that is, adding new furnaces) to the same factory again several years or even decades later, all issued to various persons or group of persons, as the ownership changed over time. Because of this, it is impossible to make a simple count of factories according to their business organisation and present a breakdown in the number of factories owned by a single individual, the number of factories owned by several family members, and the number factories owned by unrelated partners. Moreover, for the last case, it is impossible to establish with certainty whether the partners were truly unrelated to each other, as not having the same surname does not necessarily imply absence of any kin relationship.

One example can illustrate how complex the ownership structure could be. In 1828, A. Lefèvre, together with his partners (literally mentioned as *compagnons*) P. Masson, N. Andris (residents of faubourg de Charleroi), Melchior Andris (resident of Lodelinsart), Michel Andris (resident of Gilly) and L. Andris (resident of Jumet) submitted and received a permission for the establishment of a new or reconstruction of an old 'ruined' glass factory (the documents are rather unclear in this respect) in Lodelinsart.[283] The fact that several of the partners shared the same surnames (Andris) strongly suggests family ties between them, yet it remains unclear whether they had any family ties with other partners (Lefèvre and Masson). In any case, most factories were owned by a single person (or, at least, requests were submitted by a single person), making the individual proprietorship the most common ownership type of the first decades of the 19th century.

The organisation form of the limited liability company was slow to break through in the window-glass industry. This can be attributed to two major factors. First, the window-glass workshops were still small in the early 19th century in most cases. For instance, the *Verreries de la Coupe* (later the *Verreries Bennert & Bivort*), employed only 23 workers in 1813, being a very average enterprise at the time (See Part 1, Chapter 1.5). On the other hand, the establishment of a limited liability company (*société anonyme*) was a complicated matter. The 'modern' limited liability company was introduced in present-day Belgium in 1807 by the French *Code de Commerce*. According to this law, which remained effective up to 1873, the establishment of a *société anonyme* was subject to a very severe preliminary examination by

[283] State Archives of Belgium, Brussels (Algemeen Rijksarchief, ARA), Administration des mines, ancient fonds (further: ARA-Mines), nr. 777, dossier Verrerie Falleur, Lefèvre, Andris

public authorities (the Ministry of Internal Affairs). The approval of a request by the Ministry could take up to a year, or even more. All in all, the threshold for the establishment of a *société anonyme* was so high, that it was only opportune for big enterprises, which needed large amounts of capital that could most easily be acquired by issuing shares as a limited liability company. For smaller enterprises, it was just not worth the effort in most cases.[284]

The situation changed dramatically in 1873, when a new law became effective that made the establishment of a *société anonyme* much easier, reducing the role of public authorities to a formality. As a result, the number of limited liability companies increased dramatically. While between 1819 and 1873 only 533 *sociétés anonymes* were established in Belgium, by 1890 the total number of *sociétés anonymes* had reached 1,330.[285]

Most possibly the first instance of a limited liability company in the window-glass industry in present-day Belgium was that of the *Société des Verreries de Mariemont,* established on 12 September 1828.[286] This can be explained by the fact that around that time the *Verreries de Mariemont* was the largest window-glass factory in Belgium.[287] Next, two important limited liability companies were established, in 1836: the *Société des Manufactures de Glaces, Verres à Vitres, Cristaux et Gobeleteries* (*Société des Manufactures* for short) and the *Société de Charleroi pour la Fabrication de Verre et de la Gobeleterie* (*Société de Charleroi*). Both companies were controlled by large banks, which acted as holding companies: the *Société Générale*, which patronised the *Société des Manufactures*, and the *Banque de Belgique*, which patronised the *Société de Charleroi*.[288] As noted in the chapter on the economic history of Belgium, both these banks fought for the control of Belgian industry.

The control of large capital over the window-glass industry remained limited, nevertheless. Both companies comprised multiple factories representing various branches of the glass industry. For the *Société des Manufactures*, these were the lead-glass and hollow-glass factory *Val Saint Lambert* and the window-glass factories *Verreries de Mariemont*, *Verreries Jumet-Brûlotte* (owned by Adrien Drion-Querité), *Verreries du Château de Lodilensart* (owned by Adrien Drion-Querité as well) and *Verreries de Heigne* in Jumet (owned by Antoine Houtart-Dumont).[289] The *Société de Charleroi* united seven window-glass and bottle factories in the region of Charleroi.[290] Yet, the *Société de Charleroi* dissolved in 1845 already, after the retreat of the *Banque de Belgique*.[291] As noted previously, this bank experienced serious challenges around 1838-1839 and had to downscale its activities.

Apart from the *Verreries de Mariemont*, most window-glass factories continued to be operated as individual proprietorship and partnership until the second part of the 19th

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[284] Hans Willems and Frans Buelens, "Belgische vennootschapsvormen in de negentiende en de twintigste eeuw," In *Een succesvolle onderneming. Handleiding bij het schrijven van een bedrijfsgeschiedenis*. Algemeen Rijksarchief en Rijksarchief in de Provinciën Studia 104. Rev. ed., ed. Chantal Vancoppenolle (Brussels: Algemeen Rijksarchief, 2005), 171-208.
[285] Ibidem
[286] Massart, *Histoire des verreries et des décorateurs,* 18-28.
[287] *L'indépendant*, N°212 – 6e année, 30 juin 1836, édition du matin
[288] Engen, *Het glas in België*, 194.
[289] Massart, *Histoire des verreries et des* décorateurs, 20-21.
[290] Engen (ed.), *Het glas in België,* 194.
[291] Poty and Delaet, *Charleroi pays verrier*, 44.

century. By 1896, however, the majority of window-glass factories were put under the form of a limited liability company. This evolution of business organisation can be explained by two elements. First, the introduction of the tank furnace from the 1880s onwards required considerable amounts of capital. As already mentioned, this led to concentration, as small firms that could not put up the required investment simply disappeared. The investment was significant indeed, as the installation cost of a tank furnace amounted to 250,000 Belgian francs.[292] To put matters in perspective, the value of a blast furnace amounted to 300,000 Belgian francs in 1851.[293] There is, of course, a chronological gap between the 1851 and 1880s. However, it should be noted that inflation remained very limited throughout the 19th century by today's standards. For instance, the cost of living index increased by only 50% between 1830 and 1914.[294] At any rate, the purpose of this example is merely to illustrate that the tank furnaces were among the most expensive pieces of industrial equipment in the second half of the 19th century, not to provide an exact comparison.

Another reason for the rapid spread of the limited liability company in the last quarter of the 19th century was the aforementioned change in legislation of 1873, which made the establishment of a *société anonyme* much easier.

Comparative advantage

Only a few contemporary sources provide any systematic assessments of Belgium's comparative advantage. Writing in 1868, Georges Bontemps, a prominent glass technologist, stated that Belgium was competitive in in almost all possible respects, as it had lower wages and cheaper coal. Moreover, Belgian factories were located in proximity to collieries, sand quarries, soda (sulphate) factories, sources of lime and refractory materials. According to Bontemps, the price of one ton of coal amounted to 20 (French) francs in France and only 15 in Belgium, while the labour cost was 8% lower in Belgium. As a result, the production cost of one square metre of glass amounted to 1.08 francs in Belgium and 1.25 in France. Only thanks to a trade treaty was the price of Belgian glass on the French market approximately the same as that of French glass from the Nord department.

Comparing the situation in France and England, Bontemps mentioned that while fuel as well as 'ordinary' labour (not specialised workers such as glassblowers) was much cheaper in England, the labour cost of glassblowers was 8% higher in England. Interestingly, he noted as well that approximatively half of all glassblowers working in England were, in fact of French and Belgian origin. As for the production cost of English glass, Bontemps considered it roughly equal to the Belgian.[295]

More information on the comparative position between the Belgian and English window-glass industry is to be found in a monograph on the history of the British manufacturer

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[292] Ibidem, 93.
[293] Guy Vanthemsche, *De paradoxen van de staat. Staat en vrije markt in historische perspectief (negentiende en twintigste eeuw)*. Balans 13 (Brussels: VUB Press, 1998), 75.
[294] Yves Segers, "De huishuren in België, 1800-1920, voorstelling van een databank," Catholic University of Leuven, Faculty of Economics and Applied Economics, Center for Economic Studies, Discussion Paper Series (DPS) 99.15, June 1999.
[295] Bontemps, *Guide de verrier*, 404-425.

Pilkington by T. C. Barker. As noted previously in this chapter, Belgium started to 'flood' the English window-glass market from the mid-1830s and 1840s onwards. Most British contemporaries attributed this 'invasion' to the lower labour cost in Belgium, which even made up for the more expensive Belgian coal. According to R. L. Chance, writing in 1841, Belgian glass blowers could made 50% more glass a week than British, while receiving less than a half the wage of a British counterpart. Moreover, even the 'lifestyle' and 'character' of Belgian workers was regarded as advantageous to the industry alongside low wages. For example, as stated in a British consular report (quoted by Barker): 'The characteristics of the Belgian workmen are steadiness and perseverance, combined with great intelligence in working after models; their habits are not so expensive as those of English artificers; their diet is more humble – they consume less meat, and their bread is seldom purely wheaten or white in quality …' Unfortunately, despite this anecdotal evidence, any quantitative data for a comprehensive international comparison in the 19th century are lacking, save for the information provided by Bontemps in the aforementioned work (*Guide de Verrier*). Using them, Barker concluded that, while the labour cost in Belgium was indeed lower than in England, it could not have made up for the more expensive Belgian coal (when compared to the English). According to Barker, 'Their [the Belgians'] success was really due to economies in all departments for which cheap labour may have been only partly responsible'.[296] Given the unfortunate lack of any preserved detailed business records for any of the Belgian firms, this assessment should be seen as an 'educated guess' at best, as it remains impossible to confirm or qualify it.

Returning to the competitive position of Belgium vis-à-vis France, it can be remarked that Bontemps was too optimistic in his assessment of the availability of raw materials for Belgians. As will be discussed in more detail later in the chapters on fuel and raw materials, the provision of sulphate proved to be a source of semi-permanent concern, as a large proportion had to be imported from England and, occasionally, France. Even coal had to be acquired from other regions of Belgium and even foreign countries from the 1850s and 1860s onwards.

However, as expressed in the 1870 Report by the Charleroi Chamber of Commerce, Belgians themselves still considered the availability of fuel and raw materials (coal, sand and lime) as their important advantage on the international market.[297] And yet, only three years later, a new report by the Charleroi Chamber of Commerce mentioned that the French competitors could achieve an advantage with respect to fuel, as they could rely on coal from Aniche (Nord department) and the Pas-de-Calais department. Therefore, the French glass manufacturers paid only 25 (presumably Belgian) francs for one ton of coal while Belgians paid 35 francs for one ton.[298] This points to an important change that occurred shortly after 1870, when the Belgian 'fuel advantage' declined, while the French increased. It is indeed at that time that the Charleroi manufacturers started to acquire their fuel from further away, as will be discussed in detail in Part 2, Chapter 2.1.

[296] T. C. Barker, *The Glassmakers. Pilkington: the rise of an international company 1826-1976*, London: Weidenfeld and Nicolson, 1977, 117-119.
[297] Chambre de commerce de Charleroi, *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1870* (Charleroi: n. p., 1870), 45.
[298] Chambre de commerce de Charleroi, *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1873* (Charleroi: n. p., 1873), 55.

The situation was explained in more detail in 1877, when the representatives of the Belgian window-glass industry itself described their situation as disadvantageous vis-à-vis their French counterparts in a letter addressed to the (Belgian) Ministry of Foreign Affairs, as already mentioned earlier in this chapter. It should be stated that the purpose of this letter was the adjustment of custom duties for the export of Belgium glass to France, hence, Belgians were interested in emphasising their disadvantage in order to plea for a 'fairer' tariff. Nevertheless, the arguments listed are worth discussing.

The letter stated that most French window-glass factories of the Nord department had been situated in the immediate vicinity of suppling collieries, putting them in an at least equal, if not advantageous position as compared with Belgium. Belgian factories acquired most of their fuel from the collieries of Mons (Borinage), relatively far away. In fact, the French could even make an advantage of the Belgian coal from Mons, as these collieries were located closer to the French glass factories of the Nord than to Charleroi. The same goes for the sources of sulphate. While the French could take advantage of their well-developed chemical industry with the large sulphate factories of Hautmont, Chauny, Ribécourt and other localities, the Belgian domestic production of soda proved insufficient, making the Belgian soda market into a theatre of competition between the domestic (Belgian), English and French soda industries. Last but not least, the Belgians had to acquire from France itself the majority of planks that were used for the crates. On top of that, the letter stated that the labour cost had been lower in the neigbouring countries as well.[299]

The latter statement is very questionable, as all other sources point to the low labour cost as the main advantage of the Belgian window-glass industry (and Belgian industry in general), as mentioned above. On the other hand, the remarks on the raw materials, and, to a somewhat lesser degree, fuel, seem to have been fair enough, as supply problems were mentioned time and again over the decades within the *Association*'s proceedings.

The role of the low production cost as the most important comparative advantage, was reasserted by the *Association* itself in its report on the situation of the window-glass industry in 1900, 1901, and 1902.[300] However, exactly after 1900, labour costs started to appear as a disadvantage on the global market, indicating that Belgian window glass had started to become 'too expensive'. The share of labour costs within the total production cost of window glass increased by 42% between 1890 and 1905.[301] In order to 'improve' the situation (i.e. lower the production cost), the *Association* established a convention for the reduction of labourers' wages between 10% and 30% (depending on the category) in 1902-1904. The *Association* regarded the low production cost as its main comparative advantage on the international market, and, consequently, the rising wages due to the labour union's demand as the main threat.[302] The weakening of the Belgian comparative advantage on the global

[299] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877

[300] Private archive Gobbe, Association, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1900-1901-1902 (inscribed between the proceedings of 4 May 1903 and 22 June 1903)

[301] Drèze, *Le livre d'or de l'exposition de Charleroi,* Table III.

[302] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 8 février 1904

market can be explained by the introduction of glass-making machines in the United States, which allowed for lower prices.[303]

Due to the tight international competition, especially in the latter half of the 19th century, even some ‘trivial’ factors could influence the comparative advantage in certain markets. One curious example was recorded in the proceedings of the *Association des Maîtres de Verreries* in 1883. Apparently, in the course of that year, the imports of English glass to Denmark increased steadily at the expense of Belgian imports. In its report, the *Association* attributed this to the fact that the Belgian manufacturers could not use the planks (*planchettes*) for the packaging of glass, as they could not be imported into Belgium duty-free (*importer en franchise*) under the condition of further re-export (for more on the *planchette*-question, see the chapter on raw materials). This ‘anecdote’ indicates that even such a ‘trivial’ factor as the extra costs of packaging could be a decisive factor in the context of tight international competition.[304]

Somewhat paradoxically, the state of the internal market could be an important factor for the comparative position on the international market as well. Writing during the ‘American crisis’ of 1884, the *Association* described the situation as follows. The main competitors of Belgium, France and Germany, could profit from their large internal market, which was protected by customs tariffs. This allowed the manufacturers from these countries to gain more profit by maintaining relatively high prices on their protected domestic market, while setting lower prices on the international market. As for England, another important competitor, the main advantage of this country was cheap coal. The only way to compete in such circumstances was, according to the *Association*, to lower the glassblowers’ wages.[305] In 1894, the *Association* discussed a sort of proactive commercial strategy intended to ‘fight French competition’ in its own backyard by sending a few hundred crates of glass monthly to the Paris market. The *Association* presumed that even these modest quantities would disturb the internal French market, making it impossible for the French to maintain high prices on their internal market.[306] No information on the active employment of this strategy was recorded afterwards, however.

One additional factor that is important for the assessment of the comparative advantage, as yet notoriously difficult to judge, is product quality. As will be described further (see chapter on the qualities and properties of glass for more details), the criteria for the quality of glass do not feature often in the sources in general, and even if they do, an interpretation with any degree of certainty is problematic. Any explicit comparisons between Belgian and foreign glass are even more rare, and when they do occur, the quality of Belgian glass vis-à-vis that of other countries was judged rather differently. Comparing Belgian and English glass in 1868, Bontemps mentioned that the English specialised in higher quality. While Belgians still exported glass to England, these exports were mostly of lower quality. Belgian production of high-quality glass remained limited in quantity. All in all, according to Bontemps, Belgians glass was of good mid-range quality but was inferior to the top-quality English glass (French

[303] Poty and Delaet, *Charleroi pays verrier*, 103.
[304] Private archive Gobbe, Association, Brouillons II, Séance 21 décembre 1883
[305] Private archive Gobbe, Association, Originaux C, Exposé de la situation par l’Ass-on des Maîtres de Verreries
[306] Private archive Gobbe, Association, Originaux C, Assemblée Générale 2 mars 1894

glass being comparable to Belgian in his opinion).[307] This situation was affirmed by the *Association* itself, as, for instance, it recognised in 1873 that English glass was of better quality.[308] Yet, on other occasions, Belgian glass was judged more favourably. Reporting on the state of the Belgian window-glass industry in 1872, the *Official Journal of the French Republic* wrote (quote) that 'Belgian window glass is distinguished by the quality of its products. The window glass produced in Belgium is known for its 'whiteness' (*blancheur*), and clear (colourless) and coloured glass [of Belgian origin] does not have to fear comparison with any similar [foreign] product.'[309] Describing the state of the Belgian window-glass industry in particular (and of Belgian industry in general) in 1913, Lalière stated that '…Belgian [window] glass is undoubtedly the best glass produced.'[310] It should be noted that the author of these words was Belgian himself, which may have had some influence on his judgement.

A curious case of 'brand fraud' was recorded on several occasions in 1890, when Ducoffre, an agent who kept a close eye on the treatment of cargoes of glass in the port of Antwerp on behalf of the *Association* at that time, reported on several cases in which foreign (German and French) glass had fraudulently been marked as 'Belgian Glass'. The *Association* took the matter seriously and decided to undertake (unspecified) action to put an end to this abuse. This instance may be indicative of the good quality and reputation of Belgian glass on the international market. However, the 'brand fraud' was possibly motivated by considerations unrelated to the (presumably superior) quality of Belgian glass, such as custom or transport tariffs.[311] Somewhat later the same year, Mondron (the *Association's* President) noted that the French glass was exported under Belgian brands to countries that did not have trade treaties with France, hence, the 'brand fraud' was caused by the better trading position of Belgium on some markets rather than by the quality of Belgian glass.[312] The 'brand fraud' was reported on the receiving end as well in 1894, when a Belgian General Consul in Shanghai informed the *Association* of the arrival of French glass with a false brand 'Made in Belgium' (the English expression was used) into this port.[313]

Yet, in 1909 it was mentioned explicitly that the 'brand fraud' was aimed at the 'good reputation' of Belgian firms rather than at custom tariffs or any other considerations. It is likely that this 'good reputation' referred to the product quality. The *Association* was informed on this issue by the Belgian consul in Yokohama. In order to counter this abuse, Fourcault proposed accompanying every crate of glass destined for Japan with a certificate of origin with the *Association*'s mark.[314]

Last but not least, the active involvement on the part of the Belgian government contributed to the promotion of industrial exports in general, as well as to that of window glass in particular, especially from the last quarter of the 19th century onwards. The role of Belgian consuls was of special importance in this respect and was acknowledged by other

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[307] Bontemps, *Guide de verrier*, 404-425.
[308] Private archive Gobbe, Association, Originaux C, Séance 16 septembre 1873
[309] *Journal officiel de la république française*, 9 décembre 1872, 7634-7636.
[310] Lalière, "Les industries du verre," 17.
[311] Private archive Gobbe, Association, Originaux C, Séance 12 mai 1890, Séance 4 juillet 1890
[312] Private archive Gobbe, Association, Brouillons III, Séance 5 février 1892
[313] Private archive Gobbe, Association, Originaux C, Assemblée Générale 16 février 1894
[314] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 29 mars 1909

contemporaries (*Association*), and has been affirmed in recent literature as well. The exact quantification is difficult to provide, however.[315] This will be discussed further in Part 2, Chapter 2.2.

In conclusion, it can be stated that the availability of fuel and raw materials as a factor of comparative advantage diminished between approximately 1860 and 1870, as these materials (especially coal) had to be transported from further away. The role of quality is ambiguous and difficult to assess, but it seems that the assessment of Belgian export quality became more positive by the late 19th century. By the early 20th century, 'Made in Belgium' seems to have become a definite sign of quality. Low labour costs may have been one of the most important, if not the most important factor of success. The institutional network provided by the Belgian government, which supported Belgian exports by means of consular networks and other measures, was of importance as well. It will be discussed in more details in Part 2, Chapter 2.2.

Chapter 1.5: Population and location of window-glass factories

The present chapter provides an overview of the Belgian window-glass factories that existed between the early 19th century and 1914, as grouped by location. As the present study concerns window glass only, the location of other branches of the glass industry will not be researched. Nevertheless, it is interesting to note that various branches of the glass industry were concentrated in different regions. While the region of Charleroi possessed a semi-monopoly on window-glass production, the plate-glass (mirror-glass) industry was mainly concentrated in the lower Sambre region, while the goblet and hollow-glass industries were located in the regions of Borinage (Mons) and Centre (La Louvière), and crystal (lead glass) in Liège and Namur.[316]

The task of providing a complete and exhaustive list of window-glass factories proved to be too difficult within the scope of the present study. The only overview available was presented by Raymond Chambon in his exposition catalogue *Trois siècles de verrerie au pays de Charleroi* (1969).[317] Yet, this overview is rather chaotic, making the exact interpretation doubtful on many occasions. Moreover, as noted previously (see the historiography), the author has been accused of inaccuracies or even fraud on several occasions in more recent literature. As his work provides almost no references to sources, it was decided to use it with the utmost caution, and only in cases where the information on the existence of factories could be corroborated by other sources.

For the period up to 1850, the requests for all the permissions for the establishment of or changes (extensions) to factories, as preserved in the State Archives of Belgium, were used as a primary source, alongside a list from the contemporary press. Unfortunately, due to a change in regulations, there are no permissions after 1850. Moreover, only from 1880 onwards did lists of factories appear regularly (at least a few times a year) in the *Moniteur Industriel de Charleroi* as well as in other published sources, such as the trade directories.

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[315] Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913, Huberman et al., "Technology and Geography", 45-46.
[316] Kurgan-Van Hentenryk, "Industriële ontwikkeling," 230.
[317] Chambon, *Trois siècles de verrerie.*

Hence, the period between 1850 and 1880 can be seen, paradoxically, as a 'little dark age' with almost no sources on the history of individual glass factories, except for the aforementioned work by Chambon, which, not being a primary source in the first place, is of questionable reliability.

To remedy the gap in a systematic way would mean researching the individual histories of about 80 factories, scattered over a dozen communes. Even finding out the establishment dates of all these factories would have involved a labour-intensive study of sources such as the cadastral maps or the proceedings of the local councils of all of these communes (if indeed these sources had been preserved at all). The task would be even more daunting if we were to reconstruct the individual histories of all these factories in detail, with developments such as change of ownership, as it would have implied researching numerous notarial archives (which are rather infamous for their difficult accessibility) and pursuing an active engagement with the 'industrial genealogy' of dozens of entrepreneurs. Such a task seems also to be beyond the scope of the present research, even more so as it is questionable whether the knowledge of the detailed histories of all factories would contribute proportionally to the objective of the present research, i.e. the analysis of the functioning of the industrial district as a whole, and not the study of a compendium of individual firms' histories. Therefore, I have decided to limit my research mainly to the most unambiguous sources, these being primarily lists from the contemporary press. While this approach can result in the omission of some factories, I do not believe that it will dramatically change the outline of the general trends in the location patterns of factories, which is the primary objective of the present chapter.

It should be noted that the situation is better for the Centre region, as there is a finely-detailed and well-documented work on the history of the glass industry there by Daniel Massart.[318] Moreover, the brief histories of some factories in the region of Charleroi have also been researched in genealogical works by André Darquennes and Frédéric Gobbe.[319]

Charleroi region

The first mention of a glass furnace in what would later become the Charleroi region dates back to 1438. In that year, the existence of a glass furnace, belonging to Jehan Colenet, was mentioned in the village of Leernes near the *bourg* of Fontaine-l'Evêque. The activity of this furnace was mentioned again in 1531, whereby the proprietor was mentioned as Englebert Colnet (the orthography of the name had changed), and again in 1559. It is not known with certainty whether this furnace produced window glass, and/or other types of glassware. The activity of the Leernes furnace ceased somewhere in the second half of the 16th century, perhaps due to the troubles of that time (the Dutch revolt). Hence, no direct continuity between this first furnace and the later window-glass industry can be established, save for the Colnet family line.[320]

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[318] Massart. *Histoire des verreries et des décorateurs.*

[319] André Darquennes and Frédéric Gobbe, *Sur les traces de verriers: la famille Andris(se)* (Charleroi-Marcinelle: Association généalogique du Hainaut belge, 2003); Darquennes Gobbe, *Les verriers Schmidt.*

[320] Poty and Delaet, *Charleroi, pays verrier*, 21-29.

The truly continuous history of window-glass production only started in the second half of the 17th century. By the mid-18th century, the industry had become firmly rooted in the region. Despite all the changes that followed until 1914 – such as the establishment of new factories, technological developments, the development of transport infrastructure, and changing sources of fuel and raw materials – the industry basically remained in the same locations for more than one hundred and fifty years. This can be seen as a striking example of *path dependency*.

After the disappearance of the Leernes furnace, the first 'new' window-glass workshop in the Charleroi region was established by Jean de Condé in Faubourg de Charleroi in 1669. Jean de Condé was one of the first Lorraine glassblowers who settled in the region of Charleroi, more specifically in Jumet. In 1654, he married Marie de Colnet. According to Francis Poty and Jean-Louis Delaet (1986), this Marie was a 'daughter' of Englebert. This marriage could be seen as establishing a kind of 'genealogical' connection between the 'new' furnace of Jean de Condé and the long-gone Leernes furnace – if it were not for the fact that Marie married more than one hundred years after her so-called father lived! It is still plausible, however, that she was a descendant (though certainly not a daughter) of Englebert. In his monograph on the history of 'noble glassblowers' (*gentilshommes-verriers*) of the Charleroi region, E. (no full first name mentioned) Close (1928) mentioned that Marie was a daughter of Jacques de Colnet, an *équyer* (squire).[321]

Whether it was related 'genealogically' to the Leernes furnace or not, the establishment of the de Condé furnace in 1669 served as a starting point for the development path of the industry that lasted until 1914. The history of this factory itself can be provided here as a striking example of continuity, or path dependency. In 1688, it passed to Gédéon Desaundrouin, a French officer who settled in Charleroi and married Marie de Condé, Jean's daughter, in 1680. Circa 1695, Gédéon built a *château* nearby, and from that moment onwards the factory itself was known as *Verreries du Château de Lodelinsart*. Without going into too many details, it can be noted that the factory's ownership had been passed down through many renewed families of Charleroi. After several generations of the Desandrouin family, it passed into the hands of Godefroid de Saint-Roch, who was a prominent glass manufacturer during the time of the United Kingdom of the Netherlands. For instance, he supplied all window glass for the Royal Palace of Brussels. In 1826, he was awarded a subsidy of 100,000 Dutch guilders from the Fund for the encouragement of National Industry (*Fonds tot aanmoediging der Nationale Nijverheid*) by a Royal Decree. Here, a certain engineer, Chevremont, testified that his factory (the *Verrerie du Château de Lodelinsart*) was the best in Charleroi. In the same year, Godefroid de Saint-Roch received the Order of the Netherlands Lion. He was a mayor of Lodelinsart during these years as well. Yet already in 1828, he had lost 100,000 Dutch guilders due to the bankruptcy of two trading houses in Paris. This misfortune forced de Saint-Roch to sell the *Verrerie du Château de Lodelinsart* as well as the *château* itself. In 1836, it became part of the newly established *Société des Manufactures*. In the following decades, the factory changed ownership many times. In particular, it was owned in the mid- and late 19th century by Casimir Lambert and Casimir

[321] Poty and Delaet, *Charleroi, pays verrier*, 32; E. Close, *Les Gentilshommes Verriers du Pays de Charleroi* (Namur: Émile Chantraine, 1928), 23; Hervé Hasquin, *Une mutation: le "Pays de Charleroi" aux XVII^{e} et XVIII^{e} siècles aux origines de la révolution industrielle en Belgique* (Brussels: Éditions de l'Institut de sociologie, Université libre de Bruxelles, 1971), 195.

Lambert-fils who were prominent window-glass manufacturers at the time. Finally, the factory closed in 1876, the exact reason being unknown. Speculatively, it may have been unsuitable for the new types of furnaces that started to be introduced at that time, such as the regenerative and the tank furnace. This hypothesis is just an educated guess, however. At any rate, the history of this factory, which remained 'in business' on the same spot for more than two hundred years despite all the changes, provides a striking example of path dependency.[322]

A short note on the location is worth mentioning. During its establishment in 1669, the location of this workshop was described as being Faubourg de Charleroi, and sources relating to later periods mention Lodelinsart. This should not be taken as a contradiction, as the limits of communes as they existed in the 19th century did not necessarily correspond exactly with the locations as they were known in the 17th century.

Going back from this remarkable example to the general development of the industry, it is important to note that the number of glass workshops within the Charleroi region grew steadily from the late 17th century onwards. This growth is represented in a Table 8 composed by Hasquin:

Table 8: Number of glass workshops in the Charleroi region in the 18th century

	Year					
Location	1680	1700	1730	1750	1768	1785
Jumet	1	0	0	2	4	5
Charleroi	1	3	6	6	7	7
Lodelinsart	0	0	0	1	1	1
Total	2	3	6	9	12	13

Source: Hasquin, *Une mutation: le "Pays de Charleroi"*, 197.

Charleroi should be interpreted as Faubourg de Charleroi, not Charleroi *intra muros*. As remarked by Hasquin, the development of this industry stagnated in (Faubourg de) Charleroi, while Jumet became the primary centre of the industry. As will be shown further, this situation would last until the early 20th century.[323] The numbers provided by Hasquin refer to all glass workshops, regardless of their type of production (window glass, bottles, or both). Eighteenth-century data relating to the window-glass workshops specifically are to be found in a work by Armand Julin, based on the industrial census of the Austrian Netherlands of 1764, which represents the situation at that time. Hence, in 1764, there were three workshops producing window glass and bottles (two in Charleroi and one in Amblève) and two producing window glass exclusively (in Charleroi and Leuven). To give more context, there were seven workshops producing bottles exclusively: one in Bruges, one in Brussels,

[322] ARA-Mines, nr. 777, dossier Verrerie Roch and nr. 778, Verrerie Desandrouin; Poty and Delaet, *Charleroi pays verrier*, 21-29; Darquenne, *Histoire économique du département de Jemappes*, 171-179; Mac Lean, "Gegevens over de Nederlandse en Belgische glasindustrie," 121-124.
[323] Hasquin, *Une mutation: le "Pays de Charleroi"*, 197.

one in Eikevliet (a village near Bornem, at about 20 km from Antwerp), two in Charleroi, one in Ghlin (near Mons), and one in Jumet.[324]

These data illustrate and lead to a few important points. Firstly, it appears that at that time, the production of window glass was secondary to that of bottles. Moreover, the region of Charleroi still did not possess the semi-monopoly that it would acquire by the 19th century. The glass workshops of Brussels and Leuven would not survive into the 19th century (as they were never mentioned in any lists or other sources from that time). Bottles and window glass continued to be produced together in the same factories until approximately 1833. After that and until 1867, bottle glass production would develop as a specialised branch within the Charleroi region alongside the specialised window-glass production. However, after 1870, it would go into decline, partly due to the fact that the window-glass factories lured labourers away, as they offered larger wages. Only a couple of bottle factories survived until the early 20th century in the Charleroi region.[325]

As noted in the chapter on the general development of the Belgian window-glass industry, it experienced certain drawbacks due to the political turmoil of the late 18th to early 19th centuries. Nevertheless, the general trend towards growth continued. The situation of the window-glass industry within the Charleroi region shortly after Belgian independence was described in some detail by the newspaper *L'Indépendant* in 1836 (Table 9). According to this source, three main window-glass factories within the Charleroi arrondissement were the *Verreries de Mariemont*, *Verreries de Jumet* and (the aforementioned) *Verreries du Château de Lodelinsart*. *L'Indépendant* provided a complete list, which also mentioned the number of furnaces and pots for each factory. This information is indicative of their relative importance.

Grouped by location, the list appears as follows:

[324] Armand Julin, *Les grandes fabriques de Belgique vers le milieu du XVIII^e^ siècle* (Brussels: Hayez, 1903), 76-79.
[325] Poty and Delaet, *Charleroi, pays verrier*, 123-124.

Table 9: The list of Belgian window-glass factories in 1836

Location	Name of factory	No of furnaces	No of pots
Charleroi region			
Faubourg de Charleroi	Verreries Léopold de Dorlodot	2	12
	Verreries Edouard de Dorlodot	2	12
	Verreriess Henri Houtart	2	8
	Verrerie Louis Ledoux	2	8
	Verreries Demanet*	1	8
	Verreries Drapier	1	4
Jumet	Verreries de Jumet	4	28
	Verreries Emmanuel Houtart	2	12
	Verreries Jean-Joseph Ledoux	2	8
	Verreries Demanet*	1	8
	Verreries Lavary	1	8
	Verreries Charles Ledoux	1	4
	Verreries Koehl	1	6
Lodelinsart	Verreries du Château de Lodelinsart	4	24
	Verreries Mdme veuve Huart	2	12
	Verreries Frizon	2	12
	Verreries Léonard	1	8
	Verreries Falleur	1	4
Montignies-sur-Sambre	Verreries Fanconnier	1	8
Couillet	Verreries Frédéric Dedorlodot	1	8
Gosselies	Verreries Morteau	1	4
Centre			
Haine-Saint-Pierre (Mariemont)**	Verreries de Mariemont	4	32
Seneffe	Verreries de Seneffe	1	4

Source : *L'indépendant*, N°212 – 6^{e} année, 30 juin 1836, édition du matin

**L'Indépendant* mentioned two Demanet glass factories, one in Faubourg de Charleroi and the other in Jumet (*celles de M. Demanet, au faubourg de Charleroy, et à Jumet*). Possibly, both belonged to the same entrepreneur.
**The location of this factory was often described as Mariemont. However, it was located in the commune of Haine-Saint-Pierre, as no commune of Mariemont ever existed. The location name Mariemont referred to the old royal estate, located nearby.

Curiously, while *L'Indépendant* mentioned explicitly that there were 25 window-glass factories within the Charleroi arrondissement, the list provided mentioned only 23. It was noted that Koehl was planning to establish one more factory, but still there is one missing. Nevertheless, the list clearly shows the general distribution of factories. Out of 23 factories mentioned by name, the majority were located in Jumet (7), Faubourg de Charleroi (6) and Lodelinsart (7).

Interestingly, the locations of Mariemont and Seneffe were mentioned as belonging to the Charleroi region, while they would later become considered part of Centre. However, as mentioned previously, the idea of Centre as a distinct region only appeared around 1855.[326]

Unfortunately, no detailed lists of individual factories exist for the Charleroi region for the next fifty years. Virgile Lefèbvre provided a list (Table 4, already presented in the Chapter 1.4) indicating the general evolution of the means of production (although the exact source was not quoted).[327] Interestingly, if we confront the Tables 3 and 4 with the Table 9, it appears that the Table 4 (after Lefèbvre, 21 factories in 1834) provide a number of factories much closer to that mentioned in the Table 9 (after *L'indépendant*, 24 factories in 1836) than the Table 3 (after De Nimal, 32 factories in 1833). Provided the Table 8 is based on a primary contemporary source, I assume that the number provided by De Nimal was not correct, possibly due to typesetting error (32 instead of 23).

At any rate, Tables 3 and 4 indicate that the number of factories increased significantly between 1847 and 1875. Unfortunately, it is exactly this period that we are the least well informed about. Before 1850, requests for the establishment of new factories were submitted to the *Administration des Mines*, the records of which are preserved in the State Archives of Belgium in Brussels. Yet after 1850, not a single file has been preserved, indicating that the permission procedure might have changed, and the applicants were no longer required to apply via requests to the central administration. Most likely, this was a consequence of the change in legislation of 1849, as mentioned in the chapter on sources. A number of requests dating after 1850 are preserved in the local archives of Charleroi. However, these records appear to be rather unsystematic, making the effort of reconstruction (such as a list of all factories active in 1860 for instance) impossible. Even before 1850, any detailed reconstruction appears problematic due to several considerations.

By their mere nature, the requests concern the permission for establishment only. This has two consequences. Firstly, it is possible that in some cases prospective entrepreneurs did not proceed towards the actual establishment of a factory even after receiving formal permission, due to various circumstances. While it can be assumed that such instances were not numerous, they cannot be ruled out for all cases. Secondly and more importantly, unlike the starting of an enterprise, no permission was required for going out of business. In other words, while the permissions can more or less give an impression of the *rate of establishment*, they say nothing about the rate of *disestablishment*. This makes the reconstruction of a situation at a certain period of time (say, a list of all factories active in 1860) extremely difficult. Another difficulty arises from the often-ambiguous identification of factories mentioned in requests and other sources. In most cases, a geographical location or

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[326] *L'indépendant*, N°212 – 6e année, 30 juin 1836, édition du matin
[327] Lefèbvre, *La verrerie à vitres*, 48.

an owner's name was used. However, the number of factories located within a small area, and the fact that many entrepreneurs had the same last name (such as Falleur, for example) makes the identification uncertain in many cases. Therefore, as already mentioned at the beginning of the present chapter, I have decided not to try to compose lists for the period of 1836–1880, but to rely on lists that were available from the 1880s onwards.

As mentioned, the *Moniteur Industriel* regularly published detailed lists of all window-glass factories. These lists were intended to inform entrepreneurs of the current situation, which is also why the number of furnaces (active, inactive, and under construction) was mentioned. These data, known as *mouvements des fours*, provide us with important information on the relative importance of the various factories.

List (Table 10) from the *Moniteur Industriel* for September 1880 (re-arranged by location)[328]

Table 10: The list of Belgian window-glass factories in 1880

Location	Name of factory	No of active furnaces	No of inactive furnaces	No of furnaces under construction
Charleroi region				
Charleroi	Baudoux et Cie	7	3	0
	V. Brasseur et Cie	2	0	0
	C. Lambert-fils	5	7	0
Jumet	Eug. Baudoux	2	0	1
	H. J. Bivort	12	4	0
	Ed. De Dorlodot	1	1	0
	De Looper, Monnoyer et Cie	2	0	0
	J. Deulin-père	2	0	0
	J. Dessent	2	0	0
	D. Gilson et Co	2	1	0
	L. Lambert et Cie	6	0	0
	Monnoyer frères et Cie	2	1	0
	S. A. du Centre	3	1	0
	S. A. Nationales	4	3	0
Lodelinsart	A. Andris	1	1	0
	Bastin et Williams*	4	0	0
	P.-J. Cornil et Cie	1	3	0
	L. de Dorlodot et Cie	4	1	0
	Desgain frères	3	0	0
	E. Georges frères	2	0	0
	Ed. Gobbe-Hocquemiller	2	0	0
	L.-J. Goffe et A. Chausteur	3	0	0

[328] *Moniteur Industriel*, 19 septembre 1880, nr. 38

	P. L. S. Hindel	2	0	0
	L. Mondron	4	1	0
	A. Morel	3	3	0
	J. Pasquet et Co	1	0	0
	Schmidt frères et sœurs	3	1	0
	Ferd. & E. Schmidt	1	0	0
	V. L. J. Schmidt	1	0	0
	S. A. des Verreries de Charleroi	6	2	0
	S. A. de Bon-Air	3	1	0
	S. A. du Château Drion	3	1	0
Dampremy	Dulière frère et L. Greffe	2	0	0
	Fourcault, Frison et Cie	6	4	0
	Schmidt-Devillez et Co	5	1	0
	S. A. des Piges	2	0	1
Roux	A. Bougard	3	2	0
	J. Monnoyer et Cie	2	0	0
Gosselies/Courcelles**	Haidin et Co**	5	1	0
Ransart	Haubusin, Cornil et Co	2	0	0
Centre				
La Louvière	Daubresse frères	3	1	0
	A. Fagniart	3	1	0
	L. Houtart et Cie	2	0	0
Haine-Saint-Pierre	S. A. de Mariemont	4	3	0
Binche	S. A. de Binche	2	1	0
Borinage				
Jemappes	S. A. de Jemappes	3	0	0
unknown location	L. Brognon et Cie***	2	1	0

Source: *Moniteur Industriel*, 19 septembre 1880, nr. 38

*No location indicated in the list of 1880 yet indicated as located in Lodelinsart in the list for May 1885, published in *Moniteur Industriel*, nr. 21, 24 mai 1885.
**The list mentioned the location of the *Haidin et Co* factory as Gosselies-Courcelles. Presumably, the factory was located on the border of both communes. The list for May 1885, however, mentions its location as Gosselies only.
***Curiously, the list did not mention the location of this factory. Moreover, it did not appear in later lists.

The situation in the early 20th century is represented by two other lists: one from *Fabrication et travail du verre* (*Monographie industrielle*, 1907) and one from a trade directory for the regions of Charleroi, lower Sambre, Centre and Borinage (*Guide Industriel du Pays de Charleroi, Basse-Sambre, Centre et Borinage*, 1911). Unlike the previous lists, these two lists did not provide any indication of the size of the enterprises, such as the number of furnaces. Moreover, the latter did not include enterprises outside the traditional regions. Only references to the window-glass manufacturers, strictly speaking, and whether manual as well as mechanical production were included, and with clear as well as coloured glass. The manufacturers of specialty products, such as glass tubes or glass tiles, were not included. The post-processing enterprises, such as glass decoration and engraving firms, were omitted as well.

List (Table 11) from *Fabrication et travail du verre* (*Monographie industrielle*) for 1907 (re-arranged by location)[329]

Table 11: The list of Belgian window-glass factories in 1907

Location	Name of factory
Charleroi region	
Charleroi	S. A. des verreries D. Jonet
	S. A. des verreries de l'Ancre réunies (anciens établissements Casimir Lambert et Paul Hayez)
Jumet	S. A. des verreries de Jumet*
	S. A. des verreries Bennert et Bivort
	S. A. des verreries de la Marine
	S. A. Verreries Belges (anciennement Eug. Baudoux)
	S. A. des verreries des Hamendes (L. Lambert)
	S. A. des verreries de l'Espérance
Lodelinsart	S. A. Verreries de la Roue – *en liquidation***
	Henri Lambert et Cie
	S. A. Verreries de Lodelinsart (successeur de Alphonse Morel)
	E. Gobbe-Hocquemiller
	Desgain frères
	Goffe et fils
	Léon Mondron (Verreries de la Planche)
	Émile Georges et frères (Verreries du Bois Deville)
Dampremy	Émile Fourcault et Cie***
	S. A. des verreries des Piges (anciennement Cl. Misonne et Cie)
	S. A. des verreries Schmidt-Devillez
Courcelles	S. A. des verreries de Courcelles
Gilly	S. A. des verreries de Jumet*
	S. A. des verreries du Long-Bois (successeur de A. Chausteur)
Marchienne-au-Pont	S. A. des verreries de l'Étoile – *en non activité***
Centre	
Haine-Saint-Pierre	S. A. des verreries de Mariemont
Borinage	
Jemappes	S. A. des verreries de Jemappes
Brabant	
Tilly	S. A. des verreries de Tilly
Namur	
Auvelais	S. A. pour la fabrication mécanique du verre en feuilles***

[329] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 233-236.

Antwerp	
Hemiksem	S. A. les Nouvelles verreries de l'Etoile
Merksem	S. A. Antwerp Glass Works (Verreries d'Anvers)

Source: Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 233-236.

*This enterprise (*S. A. des verreries de Jumet*) was described as *à Jumet et à Gilly* in the *Fabrication et travail de verre*. It is assumed that one enterprise possessed two factories in two communes. As the primary goal of this chapter is to establish the number and location of physical production facilities (rather than firms strictly speaking), this enterprise was listed twice.
**two enterprises were indicated as inactive (*en liquidation* and *en non activité*).
***mechanical production.

Further developments are represented by the list from the *Guide Industriel* for 1911 (Table 12, re-arranged by location).[330] As in the previous one, this list includes the manufacturers of window glass (clear as well as coloured) only. The list mentioned two firms specialised in 'special glass' (*verres spéciaux*), *J. Lecomte-Falleur* in Jumet and *S. A. Verres Spéciaux de Charleroi* in Lodelinsart. The former firm was also explicitly mentioned as a window-glass manufacturer and was therefore included in the list. The latter, however, was omitted, as it was not mentioned explicitly whether it produced glass itself, or merely acted as a postprocessing workshop. As noted, this list includes enterprises within the Charleroi region only.

Table 12: List of window-glass factories in the Charleroi region, 1911

Location	Name of factory
Charleroi	S. A. Verreries D. Jonet au faubourg
Jumet	S. A. Verreries Belges
	S. A. Verreries Bennert & Bivort (La Coupe)
	S. A. Verreries des Hamendes – L. Lambert et Cie
	S. A. Verreries de l'Hermitage*
	Lecomte-Falleur (La Coupe)
	S. A. Verreries de Jumet: Verreries nationales (établissement à la Brûlotte)**
	S. A. Verreries de Jumet: Verreries du Centre (établissement R. du Centre)**
	S. A. Verreries de la Marine: Anciennes Verreries Hans**
	S. A. Verreries de la Marine: Verreries de la Marine (établissement à la Marine)**
Lodelinsart	Desgain frères
	Georges (Émile) & frères (Verreries du Bois d'Elville, Aulnitas)
	Gobbe-Hocquemiller
	Goffe & fils

[330] Hallet, *Guide industriel du Pays de Charleroi, Basse-Sambre et Borinage*, 1911, 32-41, 70, 39.

	Henri Lambert & Cie (Chenois)
	S. A. Verreries de Lodelinsart, au Chennois
	Verreries de la Planche & de l'Ancre réunies: Verreries de la Planche**
	Verreries de la Planche & de l'Ancre réunies: Verreries de l'Ancre**
Dampremy	Verreries de Dampremy (Fourcault et Cie)
	Verreries Jules Francq (anciennement Schmidt-Devillez et Cie)
	S. A. Verreries des Piges
Courcelles	S. A. Verreries de Courcelles
Gilly	S. A. Verreries du Long Bois

Source: Hallet, *Guide industriel du Pays de Charleroi, Basse-Sambre et Borinage*, 1911, 32-41, 70, 39.

*The 1907 list from the *Fabrication et travail du verre* explicitly listed this enterprise as a postprocessing decoration firm without its own glass production (p. 250). The mention within the category of *verreries à vitres* in the 1911 list of the *Guide Industriel* suggests that the firm had initiated its own glass production by then.

**In three cases, one firm possessed multiple production facilities (factories)

The comparison of the lists of 1836 (*L'Indépendant*), 1880 (*Moniteur Industriel*), 1907 (*Fabrication et travail*) and 1911 (*Guide Industriel*) illustrates several important points. First of all, there is a clear growth in the number of factories, from 23 in 1836 to 47 in 1880, indicating the establishment of many new factories. And the number of factories diminished again between 1880 and 1907. This can be attributed to the introduction of the tank furnace and the subsequent upscaling of enterprises. Yet the geographical distribution remained largely unchanged, as illustrated by the Tables 13-14-15.

Table 13: Evolution of the distribution of window-glass factories in Belgium, 1836-1880-1907-1911

Region	1836	1880	1907	1911
Charleroi (region)	23	40	23 (-2*)	23
Centre	2	5	1	-
Borinage	0	1	1	-
Brabant	0	0	1	-
Namur	0	0	1	-
Antwerp	0	0	2	-
Unknown	0	1	0	-
Total	25	47	29 (-2*)	-

Source: compilation of the tables nos. 8-11.

*Enterprises designated as inactive (*en liquidation* and *en non activité*) in the 1907 list
As appears from the table, the semi-monopolistic position of the Charleroi region, as judged by the share of the total number of factories, declined only slightly from 92% in 1836 to 85% in 1880 and 1907.

The distribution within the Charleroi region did not change dramatically either.

Table 14: Evolution of the distribution of window-glass factories in the Charleroi region, 1836-1880-1907-1911

Commune	1836	1880	1907	1911
Charleroi (faubourg)	6	3	2	1
Jumet	7	11	6	9
Lodelinsart	7	18	8 (-1)	8
Dampremy	0	4	3	3
Courcelles	0	0	1	1
Gilly	0	0	2	1
Marchenne-au-Pont	0	0	1 (-1)	0
Montignies-sur-Sambre	1	0	0	0
Couillet	1	0	0	0
Gosselies	1	1	0	0
Roux	0	2	0	0
Ransart	0	1	0	0
Total	23	40	23 (-2)	23

Source: compilation of the tables nos. 8-11.

As it appears, Jumet and Lodelinsart remained the major centres of production. The table illustrates the share of Jumet and Lodelinsart combined within the Charleroi region and the entire Belgium.

Table 15: Evolution of the share of Jumet and Lodelinsart in the total production capacity of the Belgian window-glass industry, 1836-1880-1907-1911

	Share of Jumet and Lodelinsart combined (number of factories)	
	Within Belgium	Within Charleroi region
1836	56%	61%
1880	61%	72.5%
1907*	48%	62%
1911	-	74%

Source: compilation of the tables nos. 9-11.

*Two factories that were listed as inactive in 1907 (*en liquidation* and *en non activité*) are not included in the calculation.

Apart from the prominent role of these two communes, the share of Faubourg de Charleroi declined systematically, while other communes of the Charleroi region never exceeded the relatively modest capacity of one or two factories. Dampremy emerged as the third most important production centre within the region in the second half of the 19th century, albeit by a long way. It can therefore be concluded that, despite the establishment of new factories in other locations, the development of new infrastructure (railways) and the changing geographical origin of fuel and raw materials (see Part 2, Chapter 2.1) in roughly 45 years, the traditional location pattern actually *became strengthened* between 1836 and 1880 and remained largely constant until the early 20th century. Moreover, as shown previously, this location pattern had already emerged in the 18th century. Hence, we encounter an instance of *strong path dependency* in this case.

Location of factories in relationship to infrastructure

As noted in the chapter on the urban development of the regions of Charleroi and Centre, the *Chaussée de Bruxelles*, built between 1713 and 1719, formed the backbone of the Charleroi region. As mentioned, this road formed the main transport artery for coal as well as other industrial products. While most window-glass factories were located in Jumet and Lodelinsart – communes that this road went through – it seems logical to assume that the road acted as a major location factor. This assumption can be corroborated by the research of Darquennes and Gobbe, who studied the locations of a number of window-glass factories based on the cadaster information and historic maps (plans Popp, *Atlas des Communications Vicinales*). While their sample is selective (they only examine the location of factories related to the various branches of the Schmidt family), it is plausible to assume that the factories within their sample followed the same location pattern as the window-glass factories in general. The location of factories within their sample (six in Jumet and five in Lodelinsart) shows that they clearly gravitated towards the *Chaussée de Bruxelles*, seven out of eleven being located directly or almost directly along the road, one in close proximity and three somewhat further away, although no more than a couple of kilometres away at best.[331] Later, railways replaced roads as the main means of transport, although the location pattern of factories remained unchanged, as exemplified by the case of *Bennert & Bivort* examined below.

Waterways, on the other hand, seem not to have played any role as a location factor for the majority (if not all) of the factories. To start with, Jumet and Lodelinsart were not located on any waterway. In addition, in the second half of the 19th century, water transport was almost never mentioned by the *Association*, while rail transport was frequently discussed (see Part 2, Chapter 2.2). This might seem counterintuitive, yet, as already discussed, transport over water was rare until the 19th century. Moreover, the Sambre river, being the only existing waterway before the digging of canals in the 1820s and 1830s, led to Namur, while the majority of exports (as exemplified by the *Bennert & Bivort* case) went in the opposite direction, towards Brussels and Flanders.

The dominant role of the railway for the transport of glass is attested to by the Charleroi Chamber of Commerce report of 1869, which mentioned explicitly that four-fifths of the entire window-glass production was transported by the *Grand Central Belge* railway company to Antwerp (undoubtedly for further transport to overseas destinations by ship).[332]

[331] Darquennes and Gobbe, *Les verriers Schmidt,* 23-24.
[332] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, 1869*, 37.

Apparently, the improvement of water transport infrastructure from the 1830s onwards did not cause any relocation of the window-glass factories. Rather, the entrepreneurs would ‘wait’ for the arrival of the railways. In fact, it seems that the railways followed the already-existent location pattern of the industries (at least that of the window-glass industry), as can be illustrated by the *Bennert & Bivort* case.

Bennert & Bivort: exceptional yet exemplary enterprise

As mentioned, the provision of detailed histories of all the enterprises of the Charleroi region is beyond the scope of this study. Yet one enterprise, *Bennert & Bivort*, is worth discussing in further detail here. Paradoxically, it can be described as exemplary and exceptional at the same time. It was exemplary as its history illustrates the main development stages and the general path of development of the entire industry, from a small artisanal workshop to a large industrial enterprise. At the same time, it developed into one of the largest window-glass factories in Belgium, therefore acquiring an exceptional position. Moreover, as will be discussed in Part 2, Chapter 2.2, the *Bennert & Bivort* firm played an important (if only dissident) role within the *Association des Maîtres de Verreries*, the business interest organisation of the window-glass industry.

The *Verreries de la Coupe*, as it was originally named after the hamlet in Jumet where it was located (hameau de la Coupe), was established around 1760. The exact date is unknown, yet the preserved 1809 act mentioned that it had been active for more than fifty years. Moreover, this act mentioned the name of Henry De Condé. While the exact role of this person remains unclear, he may have been the founder and first owner of the factory. In this case, the establishment of the *Verreries de la Coupe* could be connected to the De Condé family, one of the prominent *gentilshommes-verriers* dynasties of the 18th century. This remains just an educated guess, however. By 1809, the workshop was owned by Henry Joseph Houtart (or Houtard, the spelling varies), a member of the Houtart family that played an important role in the Belgian window-glass industry. In 1833, it was acquired by a certain Pierre Lavary.[333]

In the early 19th century, the *Verreries de la Coupe* produced window glass (described as *verre à vitres commun*) as well as bottles, as was typical for the Charleroi region at the time. In 1813, the workshop employed 23 workers. In 1823, the enterprise had one annealer and one melting furnace, comprising four pots for the production of bottles and two for window glass. Around that time, the most important sales markets for the production from the factory were Brussels, Ghent, Antwerp, Namur, Liège, the ‘entire Flanders’ as well as Holland. According to the document, it was impossible to provide the exact share for each of these destinations, but it mentioned as well that at least five-sixths of the total production was exported to Flanders and Holland through Brussels and Antwerp. Here, no distinction between window glass and bottles was made. Hence, the enterprise operated on the national level, if we consider that the present-day Belgium was part of the United Kingdom of the Netherlands, making Holland a part of the domestic market as well. Interestingly, the document mentions that exports to Tournai and regions along the French border remained

[333] ARA-Mines, nr 776 dossier 712

very limited due to the French competition.[334] While no means of transport were mentioned explicitly, it seems more than likely that exports to Brussels, Antwerp, Flanders and Holland were conducted via the *Chaussée de Bruxelles*.[335]

Some interesting quantitative data on the production of window glass and consumption of fuel and raw materials were recorded in a request from 1847. These data concerned two new furnaces, comprising eight pots in total. These were projected numbers, provided within the request for the construction of two new furnaces, but they are arguably representative for the size of orders at that time. Hence, according to the request, the daily production of 4,000 kg window glass required 10,000 kg coal, 800 kg sodium sulphate, 1,600 kg sand, 700 kg cullet and 700 kg lime.[336]

All in all, the *Verreries de la Coupe* was a rather modest enterprise during the 1820s and 1830s. In 1834, it possessed one melting furnace with eight pots. To put matters in perspective, the largest enterprise of that moment, the *Verreries de Mariemont*, had four furnaces with a total capacity of 32 pots (see the 1836 list above, the *Verreries de la Coupe* can most certainly be identified with the *Verreries Lavary* mentioned there).[337] In 1836, the *Verreries de la Coupe* was incorporated within the aforementioned *Société de Charleroi*.[338] However, this amalgamated enterprise did not last long, and was already dissolved by 1845.[339] It was after this that the development of the old *Verreries de la Coupe* took a decisive turn, when it was acquired by Henri-Joseph Bivort (1808-1880) and August Bennert (1811-1884). Unlike most of the glass masters active in the Charleroi region, these two entrepreneurs lacked any 'glass tradition' within their families. Bivort was born in Jumet, his father was a colliery owner and was active as an iron trader as well, while Bennert was an immigrant from Germany who settled in Belgium in 1827.[340] Bennert and Bivort started the expansion of their enterprise in 1847 by adding two new melting furnaces and four annealers. By that time, bottle production was no longer reported, and the firm began to specialise in window glass exclusively.[341] In the following years and decades, the firm grew steadily, becoming one of the largest window-glass factories in Belgium by the late 19th century. In 1870, it possessed twelve melting furnaces, while most factories only had between one and five.[342]

Apart from the purely quantitative growth, the firm played a pioneering role in the introduction and development of new technologies, as it became the first Belgian firm to

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[334] Ibidem
[335] Ibidem
[336] ARA-Mines, nr. 776, dossier 1826
[337] *Journal de Charleroi*, 21 février 1911, p. 2
[338] "Statuts Société de Charleroi," In Vol. 2 of *Collection des statuts de toutes les sociétés anonymes et en commandite par actions de la Belgique* (Brussels: Trioen, 1839), 334-338.
[339] Chambon, *Trois siècles de verrerie,* 132-135.
[340] Jean-Louis Delaet and René Leboutte, "Van kunst naar industrie: de glasnijverheid," in *Nijver België: het industriële landschap omstreeks 1850*, eds. Bart Van der Herten, Michel Oris and Jan Roegiers (Deurne: MIM/Gemeentekrediet van België, 1995), 329; Ginette Kurgan-Van Hentenryk, Serge Jaumain, and Valérie Montes, eds. *Dictionnaire des patrons en Belgique: les hommes, les entreprises, les réseaux* (Brussels: De Boeck Supérieur, 1996), 55-56; *Gazette de Charleroi*, 19 janvier 1880, p. 2-3 and 04 octobre 1884, p. 3
[341] ARA-Mines, nr. 776, dossier 1826
[342] *Journal de Charleroi*, 21 février 1911, p. 2

start experimenting with the Siemens regenerative furnaces in 1867.[343] This topic will be discussed in more detail in the chapter on technology. In 1881, the firm had 18 melting furnaces, half of them of the latest Siemens type. The first tank furnace was introduced in 1885. By 1892, *Bennert & Bivort* were using three large tank furnaces and employed 1,200 to 1,300 workers.

Auguste Bennert retired from the business in 1877, leaving Henri-Joseph Bivort as the sole owner. In 1880, Henri-Joseph was succeeded by his son Joseph and in 1892, the family enterprise was transformed into a limited liability company.[344] Interestingly, the firm name *Bennert & Bivort* was maintained even after Bennert's retirement, possibly due to the reputation and brand value associated with it. However, it seems that the firm lost its innovative spirit by the early 20th century. Unlike most other window-glass factories, it never adopted the method of mechanical production (the Fourcault method). It was the last Belgian factory to rely on manual blowing, using this method up to 1930. The last glass cylinders were blown here manually on 30 September 1930, marking the end of an era (the manual production process as practised in Jumet in 1930 can be seen in a documentary produced by the Musée de la Vie Wallone[345]). After this, the enterprise reverted to the production of bottles. In 1963, the enterprise was amalgamated into the *Boutelleries Belges Réunies* together with several other Belgian glass container factories. In 1963 it became a part of *Verlipack* (*Verreries de Liège et de la Campine*, established in 1922[346]), and finally closed in 1997, marking the end of glass manufacturing in Jumet.[347]

Despite all the changes this enterprise had experienced during its 250 year long history, its location remained the same. This fact is attested to by the aforementioned research by Darquennes and Gobbe. They identify the location of the factory as the present-day rue Joseph Wauters and rue Ledoux, near the (former) Jumet railway station.[348] As was the case with most window-glass factories of the Charleroi region, it 'gravitated' towards the *Chaussée de Bruxelles*, being located about a kilometre and a half from this road.
Later, the factory was well served by the railway. As noted, the factory was situated near the railway station, the Jumet-Brûlotte station to be exact. Moreover, it seems (almost) certain that the factory was served by an industrial branch line as well, from Lodelinsart to La Coupe (see Figure 7).[349] This industrial line branched off the Charleroi Ouest–Leuven mainline railway at Lodelinsart station, and served many industries, such as collieries, glass factories,

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343 Drèze, *Le livre d'or de l'exposition de Charleroi,* 446.

344 "Les verreries Bennert & Bivort," in *L'indépendance belge*, 25 novembre 1897, p. 2; *Journal de Charleroi*, 09 septembre 1913

345 "Le travail du verre. La fabrication du verre à vitres à Jumet, 1930. Enquête du Musée de la Vie wallone, Film n° 8000009", YouTube video. Published on 25 July 2018 [originally 1930]. Accessed on 13 March 2023 via https://youtu.be/RNElWR7YKf0

346 Suzanne Antonis, "Verlipack, de scherven van de flessenfabriek," Onderox. Fonkelende verhalen uit de Kempen. Published 25 September 2019. Accessed on 13 March 2023. https://www.onderox.be/lezen/verdwenen-industrie/verlipack-de-scherven-van-een-flessenfabriek-234715/

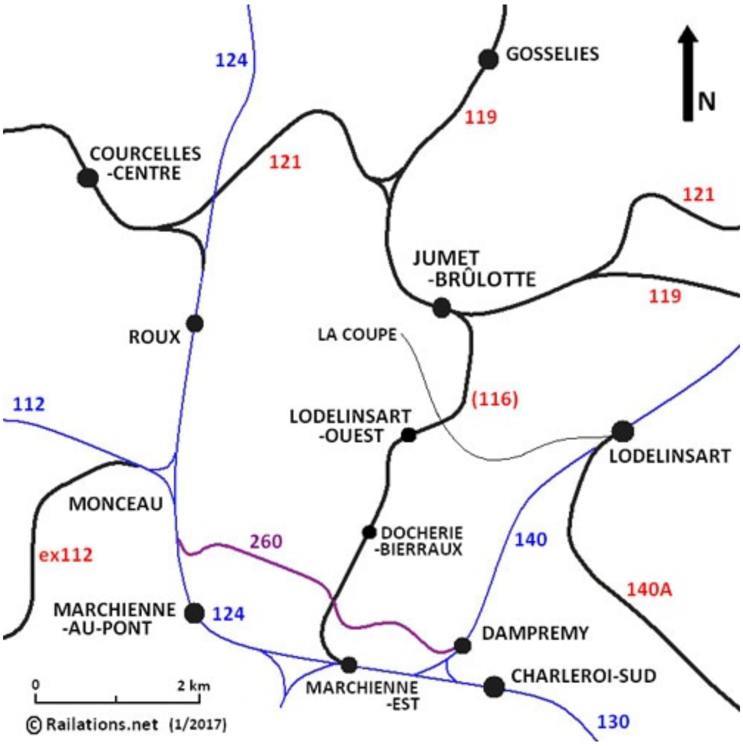
347 Darquennes and Gobbe, *Les verriers Schmidt,* 32-34; Charleroi découverte. Histoire(s) & patrimoine de Charleroi. "Les Bivort, organisateurs des vies industrielle et sociale de Jumet-Gohyssart." Accessed on 13 March 2023 via https://www.charleroi-decouverte.be/pages/index.php?id=414

348 Darquennes and Gobbe, *Les verriers Schmidt.* 31.

349 Railations, "Van Jumet-Brûlotte naar Marchenne-Est." Accessed on 18 March 2023. https://www.railations.net/jumetmarchienne.html

engineering firms and others.[350] While the detailed study of the relationship between the location of factories and transport infrastructure is beyond the scope of the present research (as it would require extensive study of cartographical sources and employment GIS), it can at least be postulated as a plausible hypothesis that the railway infrastructure adapted to the already-existing location pattern of industries, rather than the other way around. The case of the *Bennert & Bivort* factory can serve as an important example in this context.

Figure 7: Part of the railway network of the Charleroi region. Note the industrial branch line from Lodelinsart to La Coupe



Source: Railations.net, with permission https://www.railations.net/jumetmarchienne.html

The impressive ruins of the former *Bennert & Bivort* factory, with their distinctive 19th-century industrial architecture, were still standing in 2005.[351] However, the Google Earth satellite image from early 2023 shows a huge vacant lot located between rue Joseph Wauters and rue Ledoux. Not a single remnant of the former industrial glory can be spotted anymore. Hence, it can be concluded that two and a half centuries of industrial history has now disappeared without a trace. The only reminder of the once-flourishing enterprise is Bivort park, located a few hundred metres from the former industrial site (rue Joseph Bivort). As the name suggests, the park was originally the private property of Henry-Joseph Bivort, who erected his own *château* (mansion rather than castle) there in 1868. Unfortunately, the *château* was demolished in 1988 after years of neglect. The park itself, however, has been

[350] *Jumet. Nos industries au passé. Catalogue* (n.p.: Collectif mémoire ouvrière, 1988), 18.
[351] Urban Exploring. Abandoned places in Europe, "Verlipack Jumet." Accessed 18 March 2023. https://www.urbex.nl/verlipack/

open to the public since 1976 and is regarded as one of the finest within the Charleroi agglomeration.[352]

Centre region

The history of all glass factories of the Centre region is described in detail in the extensive monograph *Histoire des verreries et des décorateurs sur verre de la région du Centre* (2009) by Daniel Massart. As providing detailed histories of individual enterprises is not the purpose of the present study, only a list (Table 16) will be given here.

In general terms, the Centre region can be described as one of the four traditional glass-producing regions of Belgium, alongside Borinage, Charleroi and Liège. Yet, unlike Charleroi, it specialised mainly in the production of hollow glass, including artistic production. Out of the 23 glass factories that were established in this region between 1764 (establishment of the *Verreries de Seneffe*, the first glass factory in the region) and 1914, only six (*Verreries de Seneffe*, *Verreries de Mariemont*, *Verreries Saint-Vaast*, *Verreries Daubresse frères*, *Verreries Houtart*, and *Verreries de Binche*) produced window glass, in combination with other types of glassware in most cases.[353] It appears that not all of the Centre factories appeared in the lists published in the *Moniteur Industriel*. Presumably, this can be attributed to the insignificant levels of production at these factories.

In addition to this, some interesting differences between window-glass production in the regions of Charleroi and Centre are worth mentioning. It appears that while the Charleroi enterprises mostly specialised in the production of window glass exclusively from approximately 1830 to 1840, the Centre enterprises, with the notable exception of the *Verreries de Mariemont*, continued with combined production (window glass, bottles, and goblets in some cases) until the late 19th century. The entrepreneurship structures differed as well. While most of the Charleroi firms remained private family enterprises until the last quarter of the 19th century,[354] *Sociétés en Commandite* and *Sociétés Anonymes* (various types of joint stock and limited liability companies) had appeared in the Centre decades earlier. Hence, it seems that the two neighbouring glass-producing industrial districts had developed distinct entrepreneurial structures in the course of the 19th century. In order to answer the intriguing 'why' question, a thorough study of the Centre region, including other branches of the glass industry (goblets and hollow glass in particular) would be needed (which is beyond the scope of the present thesis).

On the other hand, both regions shared many linkages as well. For instance, several members of the Houtart family were active in both Charleroi and the Centre regions. Or, to provide another example, almost all labourers of the *Verreries Houtart* in Saint-Vaast (established in 1858) arrived from the Charleroi region.[355]

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[352] Charleroi découverte. Histoire(s) & patrimoine de Charleroi. "Le Parc Bivort." Accessed 23 March 2023 via https://www.charleroi-decouverte.be/pages/index.php?id=11

[353] Massart. *Histoire des verreries et des* décorateurs, 13-53; Massart, *Verreries et verriers du Centre,* 99.

[354] Poty and Delaert, *Charleroi pays verrier*, 93-94.

[355] Massart. *Histoire des verreries et des décorateurs,* 43.

Table 16: List of the window-glass factories of the Centre region

Location	Name of factory	Period of activity
Seneffe	Verreries de Seneffe	1764-1836
Haine-Saint-Pierre	Verreries de Mariemont	1786-1930
Saint-Vaast/La Louvière*	Verreries Saint-Vaast (aka Verreries Cappellemans, Verreries Saint-Laurent, Verreries d'en bas)	1838-1881 (no window-glass production after 1864)
Saint-Vaast	Verreries Daubresse frères (aka Verreries Centrales)	1851-1901
Saint-Vaast/La Louvière*	Verreries Houtart (aka Verreries de la Louvière)	1858-1893 (window glass production in 1863-1893)
Buvrinnes/Binche**	Verreries Laurent-Devergnies (aka Verreries de Binche)	1861-1931

Source: Massart. *Histoire des verreries et des décorateurs,* 13-53.

*It appears that the municipal borders between Saint-Vaast and La Louvière were redrawn in the second part of the 19th century
**Originally established in Buvrinnes, yet in 1875 the area where the factory was located was sold by the commune of Buvrinnes to the commune of Binche

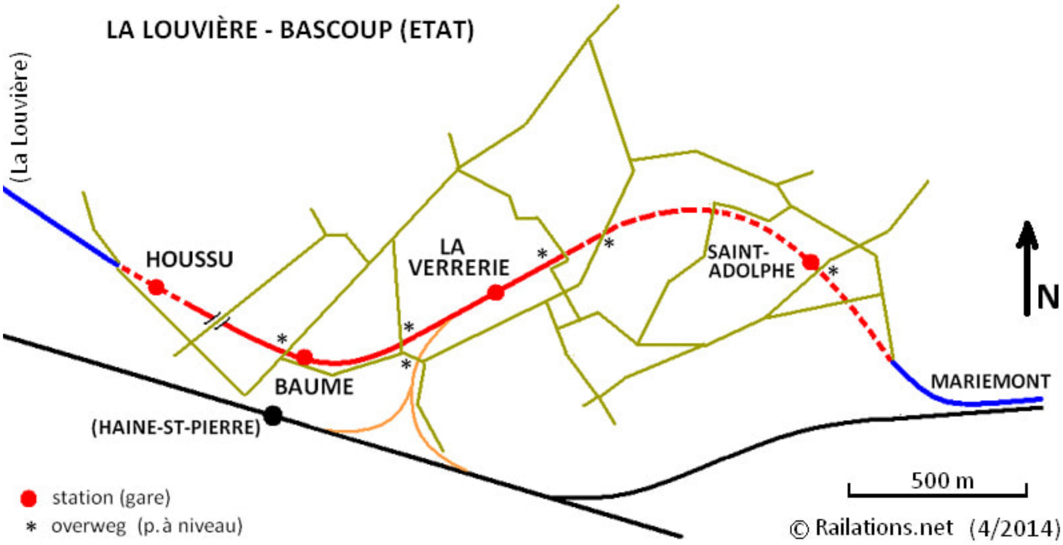
Location of factories in relationship to infrastructure

Alongside differences in entrepreneurship, the Centre enterprises differed from their counterparts in Charleroi with regard to both transport and infrastructure. While, as noted, the Charleroi factories relied on road transport first (*Chaussée de Bruxelles*) and railways later, at least one of the Centre factories was located directly alongside a canal. This is not altogether surprising given that, as already noted in the chapter on the urbanisation and infrastructure of both regions, the Charleroi–Brussels canal and its branches formed a true lifeline for the entire Centre region. Historical images (lithographs and photos) published in Massart's work show, for instance, that the Verreries Daubresse Frères was located directly on the side of the canal. A lithography from 1855 shows barges being loaded or unloaded in front of the factory.[356]

Yet the arrival of the railways was of great importance here as well. For example, the *Verreries de Mariemont* had already acquired a direct railway connection as early as 1848, when the La Louvière–Baume (Haine-Sait-Pierre)–Bascoup-Est railway line was built. It was built by the same company that constructed the Manage–Mons railway line. The La Louvière–Bascoup-Est line was intended to serve various industries (collieries first and foremost), including the *Verreries de Mariemont*. There was a station called La Verrerie located directly adjacent to the factory (Figure 8).[357]

[356] Ibidem, 41.
[357] Railations, "LA LOUVIÈRE - BASCOUP (Etat)", Belgische spoorlijnen, "Lijnen 111-120."

Figure 8: Railway with La Verrerie station



Source: Railations.net, with permission, https://www.railations.net/lalouvierebascoup.html

Borinage

While the region of Borinage did not possess much in the way window-glass production in the 19th century, it did have a long-established tradition in other branches of glass production (hollow glass). Only three firms for the production of window glass ever existed in this region, the *Verreries du Marais* in Boussu (established in 1837, with no window-glass production after 1849[358]), *Verreries du Moulineau* aka *Verreries Delobel* in Ghlin-lez-Mons (established in 1750, with no window-glass production after 1839[359]) and *Verreries de Jemappes*. The *Verreries de Jemappes*, established in 1860, is of particular interest, as it was well known for the production of extremely large sheets of glass (see more in the chapter on properties and qualities of glass).[360] Moreover, a request for the establishment of a factory for the production of window glass and bottles in the town of Péruwelz was submitted in 1838. Péruwelz is located in the Hainaut province and is generally not regarded as part of the Borinage region, but due to its proximity to Mons, it will be considered here. Interestingly, within a report accompanying the request, the 'inspector of forests' remarked that this establishment would provide competition for the glass factory of Condé. Most probably, he meant Condé-sur-Escaut just over the border in France. Possibly, competing with the French was regarded as a good thing. Nevertheless, this factory seems to have disappeared sometime after (or had not been established at all, despite the permission it received), as it has never reappeared in any source since.[361]

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[358] ARA-Mines, nr. 778, dossier 2859; Engen, *Het glas in België,* 229.

[359] ARA-Mines, nr. 778, dossier Verrerie Delobel; Engen, *Het glas in België,* 228-229.

[360] Cercle d'histoire locale Jemappes Passé-Présent, "Les Verreries." Published 13 November 2015. Accessed 18 March 2023. https://jemappes.wordpress.com/2015/11/13/les-verreries/
; Bruno Van Mol, "Actualités – quelques souvenirs des verreries de Jemappes." Patrimoine Industriel Wallonie-Bruxelles. Published 1 May 2010. Accessed 18 March 2023.
http://patrimoineindustriel.be/fr/publications/actualite/+quelques-souvenirs-des-verreries-de-jemappes

[361] ARA-Mines, nr. 778, dossier 38a

Outside of the traditional regions (Charleroi, Centre and Borinage)

Only a few window-glass factories were established outside the traditional glass-producing regions of Charleroi, Centre and Borinage before 1914. The establishment of these factories can be seen as the first move towards the decentralisation from the Charleroi and Centre regions. Most probably, decisive factors were the direct access to global markets and the relative proximity of Campine sand in the case of Antwerp, and the proximity of the main primary material (sand) in the case of Tilly. Yet, neither of these attempts were particularly successful.

Antwerp

Two window-glass factories were established near the city of Antwerp in the suburbs of Merksem and Hemiksem in the early 20th century. The *Verreries d'Anvers* (*Verreries Anversoises*), aka *Antwerp Glass Works* (established as a bottle factory in 1898 and transformed into a window-glass factory in 1905-1906) was located near the quay of the Campine canal in Merksem, while the *Nouvelles Verreries de l'Étoile* in Hemiksem was mentioned in 1907 (the exact date of establishment is unknown). The name suggests some kind of business connection with the *Verreries de l'Étoile* in Marcienne-au-Pont near Charleroi.[362]

Brabant

The only known window-glass factory in the province of Brabant was situated in Tilly. The exact date of establishment is unknown, though in 1907 it was mentioned as producing ordinary clear window glass.[363]

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[362] Helma De Smedt, "Hoe fijner glas hoe spoediger gebroken. De glasnijverheid in de provincie Antwerpen. Een korte historiek," *Post factum: Jaarboek voor geschiedenis en volkskunde* 4 (2012), 87-88; *Journal de Charleroi*, 08 janvier 1906, 2; Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 235.
[363] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 234.

Part 2: Organisation and functioning of the district

Introduction Part 2

The present part focuses on the functioning of the industrial district as both a geographical entity and a business environment. Conceptually, it builds upon the Marshallian theory of industrial districts and the 'additional' theories that can contribute to the better understanding of industrial clustering, such as location theories and theories regarding institutions (see Part 1, Chapter 1.1). Part 2 addresses several research questions.

The ***first question*** concerns whether and to what degree the location of the window-glass industry in the Charleroi region was defined by the location of fuel and raw materials. This research question is based on the location theories of the 'Weberian tradition'.

The ***second question*** addresses the role of the institutions and organisations for the functioning (and success) of the industrial district. As already discussed in the chapter on theory, the role of institutions is essential for the functioning of industrial districts, (institutions as actors), as elaborated by Porter (1990) and Edquist and Johnson (1997). At the same time, the institution-related sources (in particular those of the *Association*) provide us with a wealth of information that sheds light on the functioning of the industrial district in general, that is, going beyond the role of this institution itself. In this context, the institutions (the *Association*) and their sources serve as a '*window'* on a broader context. The second research question will focus on the former aspect (institutions as actors), while the latter (institutions as a '*window'*) will be discussed in other contexts. Hence, the second research question will be: Which institutions defined the functioning of the industrial district, what were their functions, and how did they contribute to the success of the district? Particular attention will be paid to the interactions between various levels of institutions, such as the national and the local. Moreover, the international dimension of activities is of special importance, considering the very export-oriented character of the industry. Even the *Association*, being a regional organisation, engaged actively in international matters. Given the general importance of the international dimension for the industry, a *sub-question to the second research question* can be formulated as follows: How did various institutions act at the international level, how did they cooperate at this level, and how did these actions contribute to the success of the Belgian window-glass industry? As the international activities mostly concerned the provision and exchange of information, this sub-question will be rooted in the concept of 'pipelines' (channels for the information exchange between an industrial district and the wider world, Bathelt et al., 2004). Yet not all relevant institutions will be covered in this part. In particular, the knowledge-management strategies, while being a very important institution in themselves, will be discussed in Part 3 in the context of technology and innovation. Its role in the functioning of the district in general will be discussed in the general conclusion of the thesis.

The ***third question*** addresses agglomeration effects and external economies arising in the district due to the geographical proximity of various enterprises. The question can be formulated as follows: What kind of externalities emerged in the district, and to what extent were they conducive to the further development and clustering of the window-glass industry in a small region? Two broad categories of externalities will be considered: Jacobean and

Marshallian. The labour market pooling, being one of the Marshallian externalities, will be studied from the *Association*'s accounts of the 'human resources management' (*Association* as 'window'). Conversely, the question will be addressed as to whether these factors had an effect on the location of the industry, and, if so, on what scale. It can, for instance, be assumed hypothetically, that labour would be the most 'localised' factor, while the supply of machinery would be less dependent on the distance. Yet one of the Marshallian externalities, technological externalities, will be discussed further in Part 3.

While the study of individual entrepreneurship is beyond the scope of the present research, the role of individual agency as opposed to the collective level (i.e. that of organisations) will be considered as well, as far as the sources allow. For instance, the individualistic behaviour of 'dissident firms' is sometimes mentioned in the proceedings of the *Association des Maîtres de Verreries,* which united almost all window-glass manufacturers of the region and of Belgium as a whole. Whenever possible, the specific characteristic of these 'dissidents', which set them apart from the collective, will be researched.

This part is based on the *Association*'s proceedings to a large degree. This has advantages as well as drawbacks. On the one hand, the source provides us with detailed information, originating from 'inside' the organisation. On the other, the role of other organisations, such as the Chamber of Commerce, can appear less important than it was, simply due to the fact that there are no available sources that provide detailed information on that organisation.

Chapter 2.1: Location factors

As discussed in the introductory part (Part 1, Chapter 1.1), the location of raw materials (including fuel) is regarded as one of the decisive factors for the location of industries, within the Weberian tradition, alongside the location of markets (location triangle), as represented by the already-discussed works by Alfred Weber and his followers. According to this view, industries relying heavily on raw materials (including fuel) would naturally gravitate towards the sources of these materials. It seems quite logical to assume that the window-glass industry, which was notorious for its excessive fuel demand, would closely follow this logic. Moreover, as already discussed, the Weberian logic provides an explanation for the distribution of industry on the national scale during the 19th century (Walloon axis or 'sillon industriel').

The same logic can be applied to the main primary material, sand. Moreover, following the classification principles elaborated by M. J. Webber, this industry can be described as belonging to the first group, i.e. industries most strongly bound by the local materials and fuel, and thus tending to be located in the direct proximity or even on-site with source materials, such as coal mines. From the Marshallian perspective, the availability of fuel and raw materials (sand being the most important in our case) is one of the 'primitive localisation' factors.

Forty years before Weber and more than one hundred and twenty years before Webber, Bontemps had already summed up the location factors for the window-glass industry specifically, dedicating an entire chapter of his treatise to this question. According to him, these factors were (in order of importance) the following:

1° Availability of fuel and raw materials
2° Availability of labour
3° Market outlets

Within the first category, Bontemps considered fuel more important than other raw materials. As it weighed two to three times as much as the finished product, it was much more profitable to transport the finished product than fuel. Sand ranked second in order of importance after fuel, as it amounted to approximately one half of all raw materials. Other raw materials were of secondary importance for the location of the industry.[364] This whole reasoning is very much reminiscent of the Webberian theory, whereby the window-glass industry can be clearly classified as weight-losing, therefore, tending to be located as close to the sources of fuel and raw materials as possible.

Elsewhere in his book, Bontemps provided quantitative data for the yearly production of glass and the corresponding consumption of fuel and raw materials in France (no specific year mentioned). The total production of window glass amounted to 31,000 tons. This required 24,000 tons of sand, 10,000 tons of sodium sulphate and 10,000 tons of calcium carbonate (limestone), amounting to the 44,000 tons of raw materials. After the chemical decomposition of sodium sulphate and calcium carbonate, 34,000 tons remained, while 4,000 tons got lost during the production process for various reasons (remarkably, Bontemps' calculations are out by 1,000 tons). Moreover, the production of 31,000 tons of glass required 140,000 tons of coal, used by melting furnaces as well as annealers.[365]

As for Belgium, the yearly consumption (albeit without corresponding production numbers) of fuel and raw materials for the early 20th century are provided by Drèze (Table 17; unfortunately, the corresponding quantity of glass produced was not mentioned)[366]:

Table 17: Yearly consumption of raw materials by the Belgian window-glass industry in the early 20th century

Sand	190,000 tons
Sodium sulphate	70,000 tons
Limestone	75,000 tons
Coal	540,000 tons
Wood (for packaging)	54,000 tons
Total	929,000 tons

Source: Drèze, *Le livre d'or de l'exposition de Charleroi*, 458

Hence, taking the Weberian location triangle (the location of the two most important raw materials and the location of markets) as well as the Webberian classification of industries, a hypothesis can be formulated, viz. that the location of the window-glass industry was dependent on the location of coal in the first place and that of sand in the second. As for the

[364] Bontemps, *Guide de verrier*, 219-220.
[365] Ibidem, 316.
[366] Drèze, *Le livre d'or de l'exposition de Charleroi*, 458.

market, provided that the industry catered for global consumption, the location of the main export gateways, such as ports, would be of decisive influence.

Unfortunately, the source material on the provision of fuel and raw materials before the 20th century is limited. For the period up to the mid-19th century, almost nothing is preserved, as the sources we were able to consult never mention the origin of fuel or raw materials explicitly. For instance, the requests for the establishment of factories only state that 'all materials [including fuel] originate from [this] country' without any further details. This seems to have been a standard formula that appeared in all requests in the same form.[367] There is literally only one exception to this 'rule', a request related to the *Verreries de la Couple* (later to become *Verreries Bennert & Bivort*, located in Jumet), dating from the early 19th century (from 1809 to 1823, and in 1836) which mentions some details on the origin of fuel and raw materials.[368]

Apart from this, the only source that regularly provides information on the sources of fuel and raw materials throughout a period stretching from the mid-19th century until 1914 is the proceedings of the *Association*. These proceedings contain two main types of information on fuel and raw materials, namely their origin as well as various difficulties related to their provenance, such as shortages, and the actions undertaken by the *Association* to resolve these problems. This implies that the most 'problematic' sources are mentioned most often, while 'unproblematic' ones are typically absent. Another important limitation of the source is the near total absence of any quantitative data.

While these limitations should be kept in mind, an attentive study of the proceedings can nevertheless contribute to a better understanding of the economic relationships between the glass factories and suppliers of fuel and raw materials within as well as outside Belgium, and the location factors of the industry – in addition to the agency of the *Association* itself in resolving supply problems.

Additional information on the provision of fuel and raw materials are also found in the proceedings of the Charleroi Chamber of Commerce for the second half of the 19th century. For the early 20th century, there is additional information for the sources of fuel and raw materials in the *Fabrication et travail du verre,* a monograph on the state of the Belgian glass industry published in 1907 as a part of the *Monographie industrielle* series, and in the *Livre d'Or*, a report on the state of the Belgian glass industry published after the Charleroi industrial exhibition of 1911. The latter work defined the geographical situation of Belgium as ideal for the window-glass industry, as Belgium possessed the majority of raw materials necessary as well as the main export gateway through the port of Antwerp.[369]

The following paragraphs, one on fuel (coal) and another on raw materials, will serve a two-fold goal. On the one hand, they will trace the sources of fuel and raw materials in order to investigate whether these played a role as location factors for the window-glass industry in the region of Charleroi, as predicted by the theory of Webber and followers, as well as by observations by Bontemps. On the other hand, given that the *Association*'s proceedings

[367] For example: ARA-Mines, nr. 776, dossier 1429; nr. 777, dossier 1722; nr. 777, dossier 2899.
[368] ARA-Mines, nr. 776, dossier 712
[369] Drèze, *Le livre d'or de l'exposition de Charleroi*. 458.

provide the main source for both chapters, the role of the *Association* as a governing body, and the measures it undertook to assure the provision of fuel and raw materials will be considered as well.

Fuel

As Charleroi was one of the major centres of coal mining in Belgium during the 19th century (see the chapter on the development of the Charleroi region), the provision of coal to glass factories did not receive due attention in the literature. In the 18th century, coal mining and glass production developed in close association within the region of Charleroi, especially in the Faubourg de Charleroi, as shown by Marinette Bruwier.[370] Yet, the relationship between coal mining and window-glass production became much less close in a geographical sense in the course of the 19th century, as will be shown below.

In the first decades of the 19th century, the *Verreries de la Coupe* used coal from the collieries of Gilly and Lodelinsart, as well as from the Faubourg de Charleroi. Moreover, the use of firewood (for the annealers) was reported. Its origin was described as 'forests located on both banks of the Sambre river'.[371] Unfortunately, no information on the sources of fuel is available for the following decades until the establishment of the *Association* in 1848.

The coal question was literally the first to be addressed by the *Association* upon its establishment in 1848, as a complaint in this connection was the very first text inscribed in the proceedings book, even before the proceedings of the first meeting. The request, addressed to the coal committee (*comité charbonnier*), concerned the widespread informal practice of *pourboire*, a kind of tip given by the coal suppliers to the glass factories' firemen, known as *tiseurs* in the local dialect. It is not exactly clear how this practice functioned, nor why it was regarded as such a problematic issue by the *Association*.[372] This does not matter much for the purposes of the present study. More importantly, the discussions concerning the *pourboire* question by the *Association* provide some information on the sources of coal. For instance, on 2 January 1849 it was mentioned that the complaint request was addressed to the colliers of the Charleroi region (*bassin de Charleroi*), making it clear that at that point in time, coal for the glass factories was acquired within the region itself.[373] Interestingly, the record of 16 January 1849 provides a list of collieries that were still committing the *pourboire* abuse. These were[374]:

- La société de Mambourg
- La société Sacré Madame
- La société Sacré Français
- La société des Jactions (this one is barely legible)
- La société de la Réunion
- La société Pige-au-Croly
- La société Bayemont

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[370] Bruwier, "La vie économique et sociale de Charleroi," 41-42.
[371] ARA-Mines, nr. 776, dossier 712
[372] Private archive Gobbe, Association, Originaux A, Projet d'adresse au comité charbonnier
[373] Private archive Gobbe, Association, Originaux A, Séance 2 janvier 1849, Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 366-367.
[374] Private archive Gobbe, Association, Originaux A, Séance 16 janvier 1849

- La société Terre à cailloux
- La société Devillez et Lambert
- La société Louis Lambert
- La société Ferdinand Lambert

Unfortunately, the exact locations of the collieries were not mentioned, but at least some of these collieries can be pinpointed to Charleroi and its surroundings with a high degree of certainty. For example, the toponym Pige-au-Croly still exists as a street name in Lodelinsart near Charleroi. It was first mentioned in 1443 as Piege de Crollis du Sart.[375] The toponyms Bayemont and Mambourg also exist in Charleroi as street names.[376]
On 6 March 1849, the proceedings mentioned three collieries that had not reacted to the complaint request yet. The *Association* asked its members not to acquire coal from these collieries. The collieries in question were[377]:

- Fosse Ferdinand Lambert (au Faubourg)
- Fosse Bayemont (au Faubourg)
- Société de la Réunion, à Gilly

Here, Faubourg should be interpreted as Faubourg de Charleroi, while Gilly was a suburb of Charleroi, which again proves that coal was supplied from nearby. This is still very much in line with the 18th-century situation, whereby most colliers as well as glass factories were located in the Faubourg de Charleroi.[378]

It appears that despite all its efforts, the *Association* could not force the colliery owners to stop the *pourboire* abuse. Apparently, by August 1850, a more radical solution to the problem had been proposed, namely the purchase of coal from elsewhere. It was decided to look for other suppliers that would not demand the *pourboire* bribes. More specifically, negotiations with the colliery owners of Borinage were initiated.[379]

Eventually, the first deliveries of coal that we are aware of from outside the Charleroi region took place in 1853. However, these coal loads were supplied from the Centre rather than from Borinage, several dozens of kilometres away (ca. 50 to 60 km in the case of Borinage, somewhat less for the Centre). The first 'trial orders' arrived by boat between August and October 1853. These were organised by the *Association* as a group purchase.[380] Interestingly, this is one of the very few mentions of transport by boat of coal (or any other materials). After this instance, only railways are ever mentioned.

A clear indication that the *pourboire* question was not the only reason for the *Association* to look for coal elsewhere is to be found in the proceedings of 1857. At that time, it was decided that the *Association* would make a small trial order of one or two railway wagons in

[375] Jean Everard, *Monographie des rues de Charleroi* (Charleroi: Collins, 1959), 170-172.
[376] *Stedenatlas België & Luxemburg* (Sint-Niklaas: Geocart, 2000), p. 100 – D4 ; p. 102 – A6-7
[377] Private archive Gobbe, Association, Originaux A, Séance 6 mars 1849
[378] Bruwier, "La vie économique et sociale de Charleroi," 38-46.
[379] Private archive Gobbe, Association, Originaux A, Séance 8 août 1850
[380] Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 366-367; Private archive Gobbe, Association, Originaux A, Séance 30 août 1853, Séance 4 octobre 1853, Séance 10 octobre 1853

the Centre due to the rising price of coal in Charleroi.[381] Implicitly, this suggests that the previous attempts to purchase coal outside of the Charleroi region were not successful. In 1865, the *Association* drafted a petition to the Ministry of Public Works, demanding reductions of railways tariffs for coal from Centre and Borinage, hence indicating implicitly that coal from these regions had already been used more or less extensively by that time.[382] This petition was, however, declined by the Minister of Public Works.[383]

Interestingly, some evidence suggests that the purchase of coal abroad was at least regarded as a possibility as early as the mid-1850s. For instance, in 1854, the *Association* proposed addressing a petition to the Ministry of Finances to demand the 'free entrance' of coal.[384] The possibility of purchasing English coal was discussed by the *Association* in 1865, yet this proposal was rejected for 'economic and other reasons'.[385] In 1866, the possibility and conditions of purchase of coal from the Ruhr region, including coal qualities and the price of transport, was discussed, but it is not known whether these discussions were followed by any actual purchases.[386] On another occasion, in 1867, possible purchases of coal from Ruhr, Mons (Borinage) and Liège were mentioned.[387] The transport of coal from Mons (Borinage) was discussed again by the *Association* in 1868, when Léopold de Dorlodot-fils had presented a report on his negotiations with the director of the private railway company *Compagnie du Chemin de fer de Centre* regarding the question of tariffs on coal transport, and possible reductions in particular.[388] On another occasion, in March 1873, the *Association* announced an offer of one thousand rail cars of German coal from the Ruhr. It was decided to place a trial order of 'one train' (number of cars not specified) of coal on that occasion.[389] It is not clear whether this purchase took place, however, as no further mentions were recorded.

No quantitative information on the consumption of coal from various geographical provenances by the Charleroi glass industry has been preserved. Yet, the mere fact that the transport of coal from other regions of Belgium, such as Mons (Borinage) and Centre, or even from foreign countries (Ruhr) was regularly discussed by the *Association* strongly suggests that fuel from outside the region started to play an important role from the 1850-1860s onwards. Unfortunately, the reasons why glass manufacturers decided to buy coal elsewhere is never specified explicitly, save for the rather anecdotal *pourboire* question.

One of the first mentions of the reasons for this shift to suppliers from outside Charleroi is to be found in a report published by the Charleroi chamber of commerce in 1870, mentioning that the quality of the coal of Charleroi no longer met the requirements of the window-glass industry, albeit without any further clarification. As a result, the window-glass manufacturers

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[381] Private archive Gobbe, Association, Originaux A, Séance 15 septembre 1857
[382] Private archive Gobbe, Association, Originaux A, Séance 19 septembre 1865, Séance 27 septembre 1865, Séance 16 octobre 1865
[383] Private archive Gobbe, Association, Originaux A, Séance 24 novembre 1865
[384] Private archive Gobbe, Association, Originaux A, Séance 24 décembre 1854
[385] Private archive Gobbe, Association, Originaux A, Séance 24 novembre 1865
[386] Private archive Gobbe, Association, Originaux A, Séance 19 novembre 1866, Séance 3 décembre 1866
[387] Private archive Gobbe, Association, Originaux A, Séance 16 décembre 1867
[388] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1868
[389] Private archive Gobbe, Association, Originaux C, Séance 11 mars 1873

started to turn to coal from Centre and Borinage.[390] From the 1870s and 1880s onwards, the switch to coal from outside the region of Charleroi became definitive, as the introduction of gas producers required a distinct quality of coal (described as *charbon à longue flamme* or long-flame coal*)* that was not present within the region of Charleroi. This *charbon à longue flamme* had to be delivered from the Belgian Borinage, or, even further away, from Saarland (Germany), Pas-de-Calais (France) or England.[391] While Charleroi coal was known as *maigre* (meagre), coal from Mons (in the Borinage) was also used by various industries in other parts of Hainaut (even those possessing their own coal reserves), due to its highly esteemed quality. So, the window-glass industry was not an exception when it started to acquire coal from elsewhere while being located in a coal-mining region itself. As for foreign fuel, it is known that coal from France (mostly Pas-de-Calais), Germany and England competed with Belgian coal on the domestic market in the late 19th century.[392]

However, it is interesting to note that the switch to coal from outside Charleroi did not lead to the relocation of the industry itself. Indeed, except for the *Verreries de Jemappes* and *Verreries de Binche*, there was no noticeable relocation of firms to areas closer to the new sources of fuel. Instead, while it was noted that the largest amount of fuel was acquired from Mons (Borinage) in 1877,[393] the *Association* demanded the lowering of tariffs for the transport of coal from Mons in 1879.[394] This demand was rejected by the Minster of Public Works, but this too was not followed by the relocation of firms.[395]

In 1883, it was then proposed to buy coal from Germany due to the rising price of coal (presumably referring to Belgian coal). Although this proposition was enthusiastically supported, no further details were provided. We therefore do not know whether a sort of collective provision arrangement was eventually set up. At any rate, it seems that the importance of foreign sources of fuel grew further from the 1880s onwards.[396] At the same time, the 'coal question' largely disappears from the proceedings from the mid-1880s onwards, indicating that reliable provision canals were established by then. In 1891, the *Association* decided to join forces with a similar organisation of metallurgists (*maîtres des forges*) in order to obtain a reduction on the transport tariffs for coal from the department of Pas-de-Calais by the French railway company *Chemins de fer du Nord*, whereby the reliance on foreign sources of fuel was (implicitly) reaffirmed.[397] Alongside French coal, Belgian coal from Mons was also mentioned in the proceedings a few years later, viz. in 1894 in the context of transport tariffs.[398]

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[390] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1870*, 45-46.
[391] Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 367.
[392] Marinette Bruwier, "Commerce de detail de la houille et concurrence," In *Industrie et société en Hainaut et en Wallonie du XVIIIe au XXe siècle. Recueil d'articles de Marinette Bruwier*. Crédit Communal – collection Histoire IN-8°, N°94 (Brussels: Crédit communal, 1996), 323-329.
[393] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877
[394] Private archive Gobbe, Association, Originaux C, Séance 12 mai 1879
[395] Private archive Gobbe, Association, Originaux C, Séance 25 août 1879
[396] Private archive Gobbe, Association, Originaux C, Séance 31 mars 1883
[397] Private archive Gobbe, Association, Originaux C, Assemblée Générale 29 juin 1891, Assemblée Générale 24 juillet 1891
[398] Private archive Gobbe, Association, Originaux C, Assemblée Générale 16 février 1894

A new interest in the 'coal question' was recorded in 1895-1896, leaving some interesting details (albeit still without any quantitative data) for the present-day historian. At first, an organised coal purchase in France was proposed in March 1895. The principle was approved unanimously.[399] During one of the discussions on this matter, the *Association* declared it desirable to acquire 85% of the fuel from Mons and 25% from foreign sources. France was mentioned explicitly in this regard. During the discussion, Eugène Baudoux mentioned that he already relied on French coal. A kind of *convention* for the provision of coal was adopted by the *Association's* general assembly after some discussion.[400] As French coal was a little more expensive (1.25 Belgian francs more expensive per ton compared to Belgian coal from Mons), a kind of premium system to compensate manufacturers who used French coal was elaborated by the *Association*.[401] Specifically, the Pas-de-Calais department was mentioned as a source of French coal in early 1896.[402]

In addition to France, England and Germany were mentioned as sources of fuel in the proceedings of the *Association*'s meetings on some occasions, though they were much less important than France. The 'fine coals of Newcastle', imported through Antwerp and offered by the Antwerp trading house Schellens, were mentioned in 1908, while German coal was mentioned in the general report on the state of the industry in 1913 in the context of a request for the lowering of railway tariffs.[403]

As noted, no quantitative data on the origin of coal is available. The *Fabrication et travail du verre* (*Monographie industrielle*), published in 1907, mentioned that the majority of Belgian glass factories used Belgian and French coal, while, due to the enduring rise in prices, 'certain establishments' [factories] 'recently' started to gain advantage by importing coal from Germany and England.[404] Writing around 1911, Drèze mentioned (still without any numbers) that the Belgian window-glass industry relied on domestic fuel mostly, acquiring fuel from abroad only exceptionally when the price of Belgian coal rose too high. According to him, 'a little bit' of coal was imported from Scotland in the United Kingdom, Ruhr and Saar in Germany and Pas-de-Calais in France. As for the source of Belgian coal, he mentioned Flénu, a commune in Borinage near Mons and Jemappes, at 55 km from Charleroi.[405]

In general, despite the steady growth of domestic coal production, the reliance on imported coal actually increased in Belgium in the course of the 19th century due to the even larger increase in consumption. While during the period 1831-1840 the consumption of foreign coal in Belgium only amounted to 0.08% of total national consumption, it increased to 13.53% in the period 1891-1900 and even rose to 21.29% in the period 1901-1910.[406] So, the increasing reliance on imported coal by the window-glass industry should not come as a

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[399] Private archive Gobbe, Association, Originaux C, Assemblée Générale 22 mars 1895
[400] Private archive Gobbe, Association, Originaux C, Assemblée Générale 31 mai 1895
[401] Private archive Gobbe, Association, Originaux C, Assemblée Générale 14 juin 1895
[402] Private archive Gobbe, Association, Originaux C, Assemblée Générale 28 février 1896
[403] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 30 novembre 1908; Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913
[404] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 35.
[405] Drèze, *Le livre d'or de l'exposition de Charleroi,* 458.
[406] Adriaan Linters, *De wortels van Flanders Technology. Industrieel erfgoed en Industriële archeologie in* Vlaanderen (Leuven: Kritak, 1987), 48-50.

surprise. Moreover, for window glass in particular, the quality of coal played an important role, as the gas producers required *charbon à longue flamme*.

Sand

Sand followed coal in order of importance in terms of quantity. Various sources of sand were to be found in the relative proximity of Charleroi. For instance, the *Verreries de la Coupe* mentioned the use of sand from Marbais in Brabant in 1836. Possibly, the nearby sand pits of Tilly (ca. 30 km from Charleroi) were meant.[407]

Looking at the *Association*'s proceedings, it appears that sand must have been among the least problematic materials, as it was mentioned only a few times, viz. in 1856 and 1863 in relationship to the improvement of the transport infrastructure. In both cases, the *Association* expressed its support for the petitions addressed by the owners of the Tilly sand pits to the railway administration, requiring the relocation of the railway station closer to the sources of sand.[408]

The Tilly sand pits appear to have been the main source of sand up to the last quarter of the 19th century. In 1869, the Charleroi chamber of commerce report mentioned that almost all sand was supplied from Tilly, while a (small) part was supplied from Ittre (ca. 35 km from Charleroi). Sand from Ittre was used by factories located along the Charleroi canal between Marchienne and Gosselies.[409]

In the early 20th century, the main sources of sand for window glass were to be found in the Entre-Sambre-et-Meuse region (Oret, ca. 20 km from Charleroi and Naninne, ca. 40 km) as well as in Wanze (ca. 65 km), Tilly, Havré (ca. 50 km), Binche (ca. 26 km), and Braine-l'Alleud (ca. 43 km). While none of these locations were situated too far from Charleroi, nor were any located in the direct proximity of Charleroi either. Moreover, by the early 20th century, the best (purest) sand for the best quality glass had to be acquired from the Campine (de Kempen) region in northern Flanders further away (about 150 km from Charleroi), a source that was only discovered in the last quarter of the 19th century.[410]

The Campine, a geographical (not administrative) region comprising the parts of Antwerp and Limburg provinces close to the Dutch border, remained economically underdeveloped until the mid-19th century, largely due to the poor sandy soil that limited the development of agriculture. Around 1850, a great deal of the land was still described as 'woeste gronden' (waste lands). Two laws, dating from 25 March 1847 and 27 April 1848 were intended to promote the economic development of this area. One of the infrastructure projects engendered by these laws, the Liège-Antwerp canal, literally brought to light large deposits of high-quality sand in the 1850s in the communes of Lommel, Mol and Dessel. In 1862,

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[407] ARA-Mines, nr. 776, dossier 2134

[408] Private archive Gobbe, Association, Originaux A, Séance 12 avril 1856, Séance 28 octobre 1863, Séance 10 décembre 1863

[409] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1869*, 37.

[410] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 12-13; Drèze, *Le livre d'or de l'exposition de Charleroi,* 458.

Antoon van Eetvelde acquired a permission from the Administration of Public works to commence the exploitation of sand along the canal. Soon, other entrepreneurs followed his example, leading to a true ‘sand rush’ in the area from the 1870s onwards. As a result, the high-quality sand of the Campine acquired international renown, and by the 1880s and 1890s, it was being exported to England (the glass manufacturer Pilkington being the main English client), Russia and Spain as well as, occasionally, some other countries, such as Italy and Canada. Campine sand was used by various branches of the glass industry (window glass, crystal) as well as by ceramics and some other industries.[411]

Interestingly, the first mentions of the use of Campine sand by the window-glass factories of Charleroi date back as early as 1871. A report by the Charleroi chamber of commerce in that year noted that the railway company *Grand Central Belge* started to ‘take measures’ to deliver the Campine sand to Charleroi. Previously (i.e. before 1871) it could only be transported by barges.[412] However, as already mentioned, in the early 20th century other sources of sand were still more important than Campine.

Apart from its ‘quantitative importance’, sand was essential for the quality of the glass as well, as iron oxides in particular cause brownish or greenish discoloration of clear glass, which is certainly best avoided for window glass, while being acceptable (or even desirable) for bottle glass. According to the *Fabrication et travail du verre* (1907), the best sand, containing 0.005 to 0.015% iron oxide, was to be found in Fontainebleau. It was used for the production of lead glass. For the production of higher-quality window glass, Campine sand was used, which contained 0.04% iron oxide.[413] Interestingly, Georges Bontemps mentioned already in 1868 that the sand from the (surroundings of) Namur was comparable in quality to that of Fontainebleau.[414] This may (at least partly) explain the concentration of plate-glass factories in that region, as plate glass, being a luxury product, required a better quality of sand (according to Bontemps himself). Hence, interestingly, this example illustrates how variations in quality of the final product could have an influence on the location of various branches of the glass industry.

Unfortunately, there was no mention in the *Fabrication et travail du verre* (nor in any other contemporary source I consulted) of the respective figures for sand from other Belgian sources. According to an 1883 treatise by Henry Chance, a prominent English glass manufacturer (quoted by Leen Lauriks), a maximum iron oxide proportion of 0.5% was tolerable, while ‘Waterloo sand’ contained ‘a small proportion’ of iron oxide, making it suitable for window glass.[415] No sources of sand in Waterloo are known to us, so most probably, Chance was referring to Tilly sand, using a relatively nearby location (about 30 km) well-known to his British audience.

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[411] *Bâtir sur le sable. Histoire de Sibelco et de ses minéraux* (Tielt: Sibelco, 2014), 15-67.

[412] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l’état du commerce et de l’industrie dans l’arrondissement pendant l’année 1871* (Charleroi, 1871), 58.

[413] Ministère de l’Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 12-13.

[414] Bontemps, *Guide de verrier*, 46.

[415] Henry Chance, “On the Manufacture of Crown and Sheet Glass,” *The principles of glass-making, together with treatises on crown and sheet glass* (London, 1883), 101-139. Quoted in: Leen Lauriks, “Contribution of the glass cladding to the overall structural behaviour of 19th-century iron and glass roofs” (Unpublished PhD thesis, Faculty of Engineering Vrije Universiteit Brussel and Faculty of Engineering and Architecture, Ghent University, 2012), 39.

Given the fact that the Belgian industry could deliver window glass of fair (or even superior) quality even before the use of Campine sand (See Part 1, Chapter 1.4 regarding comparative advantages and glass quality), it can be concluded that the sand from other sources (primarily Tilly) was of at least decent quality (purity). From this perspective, the glass manufacturers of Charleroi were lucky to have sources of decent-quality sand relatively close by.

Despite the obvious advantages of the Campine region, no delocalisation of the window-glass industry to this area took place before the First World War. It was not until 1921 that the first window-glass factory was established in Mol by Solvay (famous for the production of soda, see the following paragraph). Interestingly, it employed the 'imported' American Libbey-Owens method, rather than the Belgian Fourcault method.[416]

Lime

Any mentions of the origin of lime are very scarce. On one occasion in 1836, the use of lime from Landelies was reported by the *Verreries de la Coupe*.[417]

Turning to the *Association's* proceedings it appears that lime was one of the least 'problematic' materials. It was mentioned only twice, both times in 1857. On the first instance, 30 June 1857, Gorinflot and Dangneaux (no first names mentioned) proposed delivering lime to all members at the price of 10.00 Belgian francs per ton.[418] Somewhat later, on 15 September the same year, Gorinflot informed the *Association* that he was busy constructing a new machine for the grinding of lime and would be able to deliver his products in two months. By that time, he presented himself as *Gorinflot & Cie*.[419] According to Chambon, this Gorinflot was a merchant specialised in raw materials.[420] The proceedings do not mention the geographical origin of the lime provided by Gorinflot or any other supplier.

A report by the Charleroi chamber of commerce of 1869 mentioned that, 'until recently', Landelies had been the only source of lime. Yet, 'today', Montigny-le-Tilleul supplied this raw material as well. Moreover, the report mentioned that the 'pulverisation' (milling) took place at the extraction sites. Special steam-driven machines, *broyeurs* (a kind of grinding or milling machine) 'of a new type' were used for this operation. This innovation allowed for a reduction in the price, although no exact numbers were provided.[421]

In the early 20th century, the regions of Andenne, Naninne, Landelies, Montignies, Couvin and Mariembourg are mentioned as sources of lime.[422] Landelies was the closest, located

[416] Linters, *De wortels van Flanders Technology,* 156-157.
[417] ARA-Mines, nr. 776, dossier 2134
[418] Private archive Gobbe, Association, Originaux A, Séance 30 juin 1857
[419] Private archive Gobbe, Association, Originaux A, Séance 15 septembre 1857
[420] Chambon, *Trois siècles de verrerie,* 75.
[421] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1869*, 37.
[422] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 16.

only about 10 km away from Charleroi. It seems to have been the most important source of lime, too. According to Drèze, the 'excessively pure' limestone of Landelies had been discovered by a certain Mr Dolbeau [no first name mentioned] shortly after 1830.[423]

Sodium sulphate

Unlike the previous materials, which required little if any processing upon their extraction from nature, sodium sulphate, which served as a flux, was a product of the chemical industry, produced by the Leblanc method (more on this in the chapter on technology). Therefore, the location of sodium factories was arguably more important than the sources of 'rough' chemicals for the location of the factories of the window-glass industry. It should be noted that, although the first sulphate factory in present-day Belgium was established in 1822, the large-scale switch by the window-glass industry to artificial soda took place around 1834-1835. Before that time, various substances were used as flux (the so-called s*alins*, *varech*, *barilla*) by the Belgian industry, but the exact geographical origin is unknown in most cases (See Part 3, Chapter 3.3).

The first Leblanc soda factory in Belgium was established in 1822 in Laeken (Brussels agglomeration) by Guillaume Capellemans. Interestingly, it was intimately connected to the glass industry (albeit not the window-glass industry) as the soda-production facility was part of a crystal (lead glass) and hollow glass (table glassware) factory. In 1835, a sodium sulphate factory was stablished in Saint-Gilles near Brussels by the Vanderelst brothers. In 1838, another sodium sulphate factory was established as part of the plate glass factory *Manufacture de glaces de Sainte-Marie d'Oignies* in the village of Oignies near the town of Tamines (ca. 15 km from Charleroi) by François Houtart-Cossé. This factory was a part of the *Société des Manufactures*, a unique example of an enterprise uniting various branches of the glass industry (lead glass, plate glass, window glass) as well as the production of chemicals (see Part 1, Chapter 1.4). In 1843, yet another sodium sulphate factory was established in Risles (it was owned by the *Société de Vedrin*), a few kilometres outside Namur (ca. 35 km from Charleroi). In 1849, a sodium sulphate factory was established in Floreffe (ca. 25 km), followed by the establishment of a plate glass factory on the same site and under the same management, in 1853. Finally, two small sodium sulphate factories were established in 1850 in Auvelais (ca. 16 km) and in 1851 in Mornimont (ca. 22 km).[424]

The geographical distribution of the sodium sulphate factories is quite straightforward. While the two earliest were located near Brussels (Laeken and Saint-Gilles), the other four (Oignies, Auvelais, Mornimont, Floreffe, Risles) were located in the Lower Sambre (Basse Sambre) region within the Namur province, stretching from Tamines to Namur. The location of soda factories can be directly related to the glass industry in most cases, albeit not the window-glass industry specifically. The Laeken factory was adjacent to the lead and hollow-glass factory of Guillaume Capellemans, while the factories of Oignies and Floreffe were directly associated with plate-glass production, sharing the production site as well as the management and ownership of plate glass factories. No direct connection with the glass industry is known for the Morinmont and Risles factories, but as they were located in a

[423] Drèze, *Le livre d'or de l'exposition de Charleroi,* 458.
[424] Maréchal, *La guerre aux cheminées,* 43-55.

region with a vibrant plate and hollow-glass industry, it is plausible that they were attracted by the demand on the part of the glass industry as well. However, no cases of direct association between the production of window glass and sodium sulphate are known, the only exception being the *Société des Manufactures*, which owned and managed the production of sulphate (Oignies factory) as well as window glass (*Verreries de Mariemont* and *Verreries Drion* and *Verreries Houtart* in Jumet and Lodelinsart).[425] Hence, all other window-glass factories had to acquire sodium sulphate from external suppliers. The only exception was the *Verreries Saint-Vaast* (also known as *Verreries Cappellemans*, *Verreries Saint-Laurent*, *Verreries d'en bas*) in the Centre region. As in 1847, this factory produced sodium carbonate alongside various types of glassware. This is the only known example of vertical integration between the production of window glass and the chemicals necessary (sodium carbonate). In that year, the monthly sodium carbonate production amounted to 50,000 kg. An unspecified quantity of this production was offered to commerce, while the rest [presumably, the largest part] was used internally. However, this factory did not undertake the full cycle of chemical production – the sodium sulphate was delivered from the aforementioned chemical factory in Laeken, as both factories were part of the same enterprise.[426]

This raises the question of why no association between the sodium production and the window-glass industry had developed, as was the case for the plate glass industry. To begin with, the total production of window glass far exceeded that of plate glass. According to the *Fabrication et travail du verre* (1907), the yearly production of window glass amounted to 48,000,000 square metres (plus 900,000 square metres coloured and 'special' glass), while that of plate glass totalled 2,400,000 square metres.[427] Hence, the window-glass industry certainly generated a much higher demand for raw materials. On the other hand, the plate-glass factories (*glaceries*) were much larger than the window-glass factories (*verreries*) as the plate-glass production process required much more machinery (such as glass-polishing machines) and, hence, capital. For instance, according to the 1910 industrial census, an average engine power per factory amounted to 2,295 hp (horsepower) for the plate-glass factories and only 46 hp for the window-glass factories.[428] Therefore, being much larger enterprises, the plate-glass factories could finance horizontal integration, establishing adjacent sodium factories for (presumably) own consumption in the first place.

On one occasion, an idea to form a 'cooperative society' (*société coopérative*) for the production of sulphate by the window-glass manufacturers themselves was proposed in October 1895. The capital needed was estimated as high as 600,000 Belgian francs, while the forecasted annual production would amount to seven thousand tons.[429] However, due to the fact that glass manufacturers were not intended to provide the necessary capital, the project was abandoned in 1896. Interestingly, production of sulphate 'by the means of new process' had been mentioned, unfortunately without any technical details.[430]

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[425] Ibidem, 43-55.
[426] Massart, *Histoire des verreries et des décorateurs,* 31-38.
[427] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 205.
[428] *Office du travail de Belgique. Recensement de l'industrie et du commerce (31 décembre 1910),* Vol. VIII, 272, 267, 269.
[429] Private archive Gobbe, Association, Originaux C, Assemblée Générale 28 octobre 1895
[430] Private archive Gobbe, Association, Originaux C, Assemblée Générale 13 juillet 1896

As for the production quantities, a couple of examples can be provided. In 1850, the Risles factory produced 1,290 tons of sulphate, while in 1861, the entire yearly production of the province of Namur (that is, the four factories of Lower Sambre) amounted to 9,000 tons of sodium sulphate and carbonate.[431] If we are to base ourselves on the figures provided by Bontemps and presented at the beginning of this part, this would roughly suffice for the production of about 27 thousand tons of window glass (in France, the production of 31,000 ton glass required 10,000 ton sodium sulphate). At the same time, it is known that the Belgian exports of window glass in 1860 amounted to 30,228 tons, falling back to 24,046 tons in 1861 due to market fluctuations.[432] While the domestic production of sodium sulphate seems to have been sufficient in 1861, it should be kept in mind that the Oignies and Floreffe sodium factories supplied their own plate-glass factories primarily, which meant that the window-glass industry could only buy 'leftovers'. It is, therefore, by no means surprising that sodium sulphate proved to be the most problematic of all raw materials despite the fact that Belgium possessed multiple sulphate factories. Indeed, the *Association's* proceedings attest to the fact that domestic production remained insufficient throughout the entire 19th century.

The question first appeared on the agenda in 1850, when Dominique Jonet proposed drafting a petition to the government in order to demand the abolition or reduction of import duties on this commodity. It was proposed to ask the assistance of the Charleroi chamber of commerce for the drafting of the petition.[433] Subsequently, multiple petitions demanding the reduction of import duties on sodium sulphate were addressed by the *Association* to various government bodies in 1852, 1855, 1856, indicating the importance of foreign sources of this material.[434] The production of sodium sulphate in Belgium remained insufficient at the time, as was attested during the series of negotiations between the *Association* and the Belgian manufacturers of sodium sulphate, on multiple occasions around 1856.[435] In 1865, the situation was even described as *sulphate-urgence*, as a new series of negotiations was conducted between the *Association* and the sulphate suppliers, domestic and foreign.[436]

Demands (petitions) for the reduction of import duties or the introduction of 'free entry' of sulphate appeared time and again within the *Association's* proceedings over the following years, for example in 1867 and 1870.[437] The transport of sulphate by railway from Antwerp to Lodelinsart was mentioned explicitly in 1868, pointing to imports from overseas.[438]

Mentions of Belgian sulphate manufacturers became very rare within the *Association's* proceedings after 1865. In 1873, the President informed the *Association* about his

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[431] Maréchal, *La guerre aux cheminées,* 43-55.
[432] Lalière, "Le verre en Belgique," 615.
[433] Private archive Gobbe, Association, Originaux A, Séance extraordinaire 18 juin 1850
[434] Private archive Gobbe, Association, Originaux A, Séance extraordinaire 14 février 1852; Originaux A, Séance extraordinaire 2 avril 1852 ; Private archive Gobbe, Association, Originaux A, Séance 5 novembre 1855, séance 3 janvier 1856
[435] Private archive Gobbe, Association, Originaux A, Séance 5 novembre 1855, séance 3 janvier 1856 ; Séance 31 mai 1856 ; Séance 5 juillet 1856 ; Séance 29 juillet 1856 ; Séance 31 juillet 1856 ; Séance 14 août 1856 ; Séance 20 août 1856
[436] Private archive Gobbe, Association, Originaux A, Séance 21 octobre 1865
[437] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1867, Séance 14 mars 1870
[438] Private archive Gobbe, Association, Originaux A, Séance 11 mai 1868

negotiations with the committee of Belgian sulphate manufacturers, represented by Houtart-Cossé, yet no practical outcome of these negotiations is ever mentioned in the proceedings.[439] It seems, therefore, that while the window-glass industry relied at least partially on the Belgian sodium manufacturers before 1856, it clearly turned to foreign sources afterwards.

The purchase of English sulphate was mentioned in 1864,[440] while the transport of sulphate by railway from Antwerp to Lodelinsart was mentioned explicitly in 1868, pointing to imports from overseas, possibly from England.[441] The Charleroi chamber of commerce report of 1869 mentioned that both Belgian as well as English sulphate was used. According to the report, 6,362 tons (6,362,828 kg exactly) were imported from England for use by Belgian window-glass factories in 1869. Unfortunately, no figures for the consumption of domestic sulphate were provided.[442]

Though England seems to have been the primary foreign source of sulphate, France was mentioned at least once on this subject as well, as in 1873 the *Association* acquired 500 tons of sulphate from the Ribécourt factory. The price of 13.50 Belgian francs (possibly, per 100 kg) had been announced, while adjustment up to 13.75 was seen as possible if the supplier demanded it.[443] Provision by English sulphate was mentioned again in 1874.[444]

It cannot be ruled out that Belgian manufacturers still provided at least a share of sulphate consumed by the Belgian window-glass industry in the latter part of the 19th century. Yet, despite the lack of quantitative data, the persistent demands for the lowering of import duties indicates that foreign sulphate played a large, if not vital, role in supplying the Belgian window-glass industry. In 1877, it was noted that the Belgian sulphate market proved to be a 'theatre of competition' between the domestic (Belgian), English and French suppliers.[445]

Mentions of the 'sulphate question' disappeared almost completely afterwards, implying normalisation of the situation. Unfortunately, this leaves us largely ignorant on the sources of sulphate (Belgian or imported) for this period. Yet, on one occasion in 1881, the *Association* demanded the reduction of transport tariffs on the English sulphate imported by the *Grand Central Belge* railway company (undoubtedly, from the port of Antwerp), implying that imported sulphate still played a role.[446]

The importance of English sulphate should not come as a surprise. The Leblanc process for the production of sodium sulphate was introduced in England in the 1820s. After this it developed quickly, exceeding French output by a factor of three in the 1850s.[447] Writing

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[439] Private archive Gobbe, Association, Originaux C, Séance 31 mai 1873
[440] Private archive Gobbe, Association, Originaux A, Séance 2 novembre 1864
[441] Private archive Gobbe, Association, Originaux A, Séance 11 mai 1868
[442] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1869*, 36.
[443] Private archive Gobbe, Association, Originaux C, Séance 23 janvier 1873
[444] Private archive Gobbe, Association, Originaux C, Séance 23 mai 1874
[445] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877
[446] Private archive Gobbe, Association, Brouillons I, Séance 11 novembre 1881
[447] Joel Mokyr, *The Level of Riches. Technological Creativity and Economic Progress* (New York and Oxford: Oxford University Press, 1990), 107.

around 1911, Drèze mentioned that the Belgian chemical industry could provide only some of the sulphate needed for window-glass production. According to him, the most important foreign sources of sulphate were France and Germany, while the English imports had declined considerably 'in recent years'. He did not provide any quantitative data, however.[448]

Pottery clay

Pottery clay may seem like an unlikely raw material for the window-glass industry. However, it remained essential until the introduction of the tank furnace, as it was used for the production of glass-melting pots (crucibles) as well as, possibly, a material for furnaces or annealers. After the introduction of tank furnaces, pot furnaces (and, hence, crucibles) were still used for the production of coloured and special glass.[449]

Pottery clay must have been the least problematic of materials, as it featured only once in the *Association's* proceedings in 1879, when the *Association* petitioned for the 'declassification' (that is, the reduction of railway tariffs by applying a lower tariff class for the transport of this specific material) for the 'earth of Andenne' (*terres d'Andenne*).[450] The 'earth of Andenne' undoubtedly referred to the pottery clay (*argiles plastiques*) that was mined in this Belgian town (province of Namur) from the Middle Ages into the 20th century and beyond. It had been used in various branches of ceramics production, including pottery, bricks, tiles and so forth, as well as for the manufacturing of refractory materials for multiple 'fire industries', such as the metallurgy and glass industries.[451] It may be assumed that manufacturers could also acquire this material, be it from Andenne or other geographical origin, on an individual basis, as no collective arrangement for the provision of pottery clay had ever been mentioned in the proceedings.

It is not known with any certainty why (at least some) glass manufacturers decided to acquire pottery clay from Andenne, a relatively distant location (about 50 km from Charleroi). Possibly, the explanation lay in the good quality of the clay. In fact, in the time of pot furnaces, the quality of material for crucibles was of great importance for glass production. For instance, Bontemps dedicated an entire chapter of his treatise to crucibles, including the considerations of the chemical composition and quality of suitable clay.[452] It is possible that good clay could be acquired closer to Charleroi. For instance, the nearby towns of Bouffioulx and Châtelet were known for their ceramic production, although it is not clear whether the clay for these locations was suitable for the glass-melting crucibles.[453]

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[448] Drèze, *Le livre d'or de l'exposition de Charleroi,* 458.
[449] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 43-45.
[450] Private archive Gobbe, Association, Originaux C, Séance 12 mai 1879
[451] Eric Goemaere, Pierre-Yves Declerq and Yves Quinf, "Vingt siècles d'exploitation des argiles plastiques d'Andenne (Belgique): du gisement au musée de la céramique," *Annales de la Société Géologique du Nord* 19, 2ème série (October 2012): 87-97.
[452] Bontemps, *Guide de verrier*, 112-136.
[453] D.-A. Van Bastelaer, *Les grès wallons, grès-cérame ornés de l'ancienne Belgique ou des Pays-Bas, improprement nommés grès flamands* (Mons and Brussels: Hector Manceaux and G.-A. Van Trigt, 1885)

Wood

Last but not least, and rather surprisingly, wood appears to have been an essential and 'problematic' material as well. More precisely, issues concerning planks for the crates (*planchettes*) appeared within the *Association's* proceedings time and again, just as was the case with sodium sulphate. The *planchette* question first featured in the proceedings in 1858, when the *Association* decided to draw up a petition to the Ministry of Finance in order to acquire the right of 'free entry on condition of re-export'.[454] Many more petitions and letters were sent by the *Association* to the government to demand the reduction of import duties or the introduction of 'free entry' over the following years, for instance in 1863, 1866, 1870, 1873.[455] These instances indicate that this material was acquired from abroad. In 1877, it was noted that the majority of wood for crates had been acquired from France.[456] According to Drèze, in the early 20th century, packaging wood was imported from Sweden, Norway and Finland almost exclusively through the port of Antwerp, while very small quantities were imported from Hungary.[457]

Location factors: Conclusion

It appears that the importance of geographical proximity of raw materials and fuel as a location factor for the window-glass industry decreased throughout the 19th century. Belgium as a whole may have been in an 'ideal position' for the location of the glass industry as far as the sources of fuel and raw materials are concerned, but this assumption did not apply to the region of Charleroi specifically, at least from the 1850s onwards.

As already discussed in the chapter on the general evolution of the Charleroi region, coal must have been one of the main factors (if not the defining factor) for the localisation of the glass industry in the surroundings of Charleroi. As already noted (Part 1, Chapter 1.4), initially the glass industry developed in close dependency with coal mining. However, the role of coal as a location factor for the glass industry in the region of Charleroi started to decline from approximately the 1850s onwards. While the availability of coal from neighbouring regions (Mons (Borinage) and Centre) still mattered, the presence of collieries in close proximity to the glass factories ceased to be a decisive factor. Later, from the 1870s and 1880s onwards, the industry definitively switched to coal from other regions of Belgium (Mons) and even from abroad (mostly Pas-de-Calais in France). It can be stated with certainty that from this moment on, the availability of fuel did not play a role as a location factor for the window-glass industry within the Charleroi region.

The reasons for the first moves towards coal from outside the Charleroi are not exactly clear, save for some vague mentions of 'insufficient quality'. Yet, later developments are easily explained by changes in technology. As noted above, the gas producers for new types of furnaces, introduced in the 1870s and 1880s, required the so-called *charbon à longue flamme* that needed to be imported from elsewhere. In fact, as noted above, the *Association*

[454] Private archive Gobbe, Association, Originaux A, Séance 28 décembre 1858
[455] Private archive Gobbe, Association, Originaux A, Séance 28 octobre 1863, Séance 26 novembre 1866, Séance 21 février 1870, Originaux C, Séance 23 janvier 1873
[456] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877
[457] Drèze, *Le livre d'or de l'exposition de Charleroi,* 458.

even tried to gain an advantage from the situation by setting Belgian and foreign (French) coal suppliers against each other, hoping to lower the price.

The sources of raw materials cannot fully explain the location of industry either. The sources of sand, which can be seen as the most important material in terms of weight, were located at about 30 km outside Charleroi. While not too far away, this was still outside the Charleroi industrial district. However, if we assume that the local coal deposits were the initial factor for the location of the glass industry in the Charleroi region, the location of other raw materials can nevertheless be seen as still relatively advantageous (that is, not too far away). Nevertheless, from the last quarter of the 19th century on, when Campine sand started to be exploited, this material was acquired from even further away. Of all raw materials, only the sources of lime were located close to Charleroi at about 10 km. The sodium sulphate factories were located at distances of 15-35 km, yet the large majority of this material had to be imported from abroad anyway, at least from approximately 1850 onwards.

All in all, it can be concluded that the role of the sources of fuel and raw materials for the location of the industry diminished in the course of the second half of the 19th century, as these sources 'moved' further away, from the region of Charleroi itself to Mons in the case of coal and from Tilly and other locations within 30 or so km from Charleroi to the Campine in the case of sand. And yet, no delocalisation of the industry occurred until after the First World War, with a few exceptions. Neither did the main export hub, Antwerp, attract the glass industry, with a couple of (not very successful) exceptions.

This is a remarkable conclusion, as it contradicts the assumption of Bontemps who considered the availability of fuel and raw materials as the most important location factor. The same goes for the Weberian theory. Despite the lack of quantitative data, the angles of the location triangle can be associated with the sources of coal and sand (most important raw materials), and the port in Antwerp (the market, or, in our case, the gateway to the market). Yet, despite the changing 'spacial geometry' of this triangle, no delocalisation occurred. The same goes for the Webberian approach, which would imply that the window-glass industry, due to its huge demand for fuel and raw materials, belonged to the category of industries most strongly bound by the local materials and fuel, thus tending to be located in the direct proximity or even on-site with source materials.

Nevertheless, the emergence and initial development of window-glass production in the region of Charleroi, in the 17th and especially 18th century, can in large degree be attributed to the presence of coal as a 'primitive localisation' factor in Marshallian terms. As appears from the treatment of *pourboire* abuse, the local sources of coal were still employed circa 1850. Therefore, it can be concluded that the role of local sources of coal as a 'primitive localisation' factor remains valid for the period until the middle of the 19th century.

In conclusion, the Weberian logic of location factors can explain why window glass production was established in the region of Charleroi in the 18th century (and earlier), but not why it stayed there in the second half of the 19th century. The development of infrastructure, such as railways and canals, certainly played a role here, as it allowed for the sourcing of fuel and raw materials from further away, making it easier to stay. However, even the improved transport infrastructure still engendered certain transport costs, which could be avoided if the industry moved closer to the sources of fuel or raw materials. Hence, a more in-depth explanation is necessary.

Hypothetically, the fact that the industry did not relocate can be explained by the 'compound localisation' factors such as the professional community of highly skilled workers, or the presence of suppliers of specialised equipment in the region, i.e. external economies. This hypothesis will be further assessed in the chapter on the agglomeration effects and externalities.

Chapter 2.2: Institutions and Governance

This chapter will look at the 'sub-surface' mechanisms that assured the functioning of the industrial district. It will regard institutions as actors that define to a large degree how industrial districts function. They provide important incentives, such as the management of conflicts, stimulation of innovations and so forth. Here, a special emphasis will be put on the mechanisms (institutions and governance structures) that were exclusive to the district. The purpose is to answer the second research question: Which institutions defined the functioning of the industrial district, what were their functions, and how did they contribute to the success of the district?

Relevant institutions

As already discussed in the chapter on institutions in the introductory part, institutions, as regarded within the neo-institutional approach, are to be seen as a broad concept, encompassing both 'institutions as concrete things' (organisations) as well as 'institutions as patterns of behaviour' (both 'formal', such as laws, and 'informal', such as customs and traditions). In the present chapter, the emphasis will be on the former type of institution (organisations), as the latter type, despite its clear importance, is difficult to ascertain from the existing sources. However, the role of informal training of glassblowers (the transmission of skills), which can be regarded as an institution as a pattern of behaviour, will be addressed in Part 3 as far as sources allow.

Despite their differences, all institutions can be seen as a means towards the reduction of transaction costs. In particular, institutions can be conducive to innovations by fulfilling three important functions:

- Reducing uncertainty by providing information
- Managing conflicts and cooperation
- Providing incentives

Hence, the following paragraphs will explore how and to what degree various institutions, acting at various levels (national and regional) contributed to the success of the district by fulfilling the aforementioned functions. Some of the relevant institutions are further discussed elsewhere in this study, as they were interlinked with specific topics studied in detail in other chapters. For these cases, only a brief summary will be provided in this chapter.

The first outline of a structure of (most) relevant institutions can be provided as a scheme:

- Institutions
  - National level
    - Patenting legislation
    - Organisation of (international) trade and (international) promotion
    - Organisation and logistics of transport
  - Regional level (business interest associations)
    - Non-specific: Chamber of Commerce
    - Specific: *Association des Maîtres de Verreries* (sectoral business interest organisation)

The *national-level institutions* were of evident importance for the entire Belgian industry. While obviously not being exclusive to the district of Charleroi, they should be discussed here as well. While these national institutions cannot be seen as defining for the concentration of the window-glass industry within this region, they clearly had a large influence upon it. Moreover, as will be demonstrated later, interactions between the national- and regional-level institutions occurred on a regular basis.

The *patenting legislation* was of great importance for the way knowledge was 'managed' and innovations were developed. As already mentioned in the general introduction, it can be seen as reducing uncertainty for inventors, as it defined who could be sure to benefit from a temporary monopoly on an invention and for how long. The role of patenting will be discussed in detail in Part 3, Chapter 3.2. For now, it can be mentioned that it was indeed applied widely within the glass-making community of the Charleroi region.

The *organisation and logistics of transport* depended on the interactions of institutions belonging to various levels as well. The railway and maritime transport in particular (the most important for the window-glass industry, as described previously), depended on the national-level State and private institutions. For instance, the State defined the overall transport policy (see chapter on the development of infrastructure) and acted as a transport company itself (the State Railways). The private sector was involved in the case of the *Grand Central Belge* railway company and various shipping companies that served the Port of Antwerp. However, as will be discussed in detail later, the regional-level institutions such as, primarily, the *Association*, played an important role in the streamlining of the transport policy to make it fit the specific requirements of the window-glass industry.

The *organisation of (primarily international) trade and promotion* was of paramount importance for the export-oriented industry such as the production of window glass. The importance of international activities, such as the establishment of information networks, e.g. Belgian consuls abroad, for the success of the Belgian window-glass industry merits special attention. Therefore, this topic will be regarded as a sub-question in its own right, namely: How did various institutions act at the international level, how did they cooperate at this level, and how did these actions contribute to the success of the Belgian window-glass industry? The interaction between the national and regional level (*Association des Maîtres de Verreries*) was of special importance in this context and will thus receive special attention. Conceptually, the concept of 'pipelines' (Bathelt et al., 2004) will be employed. The necessary context regarding the position of Belgium on the global market will be provided as well.

During the period under consideration, *business interest organisations* functioned primarily at the regional level; therefore, they can be seen as *regional-level institutions*. They can be further divided into two categories, the non-specific to the region and industry (chambers of commerce that existed in many localities) and the specific to both region and industry. As it is our purpose to research the particular arrangement of the window-glass industry within the region of Charleroi, the emphasis will be on the latter category.

In his study of the (primarily) Dutch business interest organisations, Frans van Waarden defines them as follows: 'These [business interest organisations] are defined as formal organisations of groups of business people which have as their goal the aggregation, definition, representation and defence of the group's business interests. The interests may be of a social, economic, commercial or technical nature and hence the definition comprises both employers' associations (organizing labour market interests) and trade associations (representing economic and technical interests).'[458] Hence, business interest associations (henceforth BIA) will be used further as the most general term. Both 'general' chamber(s) of commerce as well as the industry-specific *Association des Maîtres de Verreries* fit this definition.

Chambers of commerce existed in many Belgian cities, including Charleroi, throughout the 19th century. While their institutional character changed profoundly in 1875 (more on this later), their main objective remained the same, namely to unite and represent local entrepreneurs and industrialists and to establish various types of contacts with the municipal, provincial and national authorities.

Unlike the chambers of commerce, the *sectoral business interest organisations* (employers' organisations) were quite often specific to a particular region and/or industry. For the present case, the *Association des Maîtres de Verreries* (henceforth *Association*) will be studied, as it was undoubtedly the most important organisation uniting the majority of the Belgian window-glass industry, being specific to the industry and the region, and focused on many aspects of the functioning of the industrial district. Therefore, it can truly be seen as the main governance body for the window-glass industry. Moreover, the *Association des Maîtres de Verreries* acted as a cartel quite often. Therefore, a brief discussion of cartels is appropriate here too. According to a definition provided by Ervin Hexner in his classical work International Cartels (1945), 'A cartel is a voluntary, potentially impermanent, business relationship among a number of independent, private entrepreneurs, which through co-ordinated marketing significantly affects the market of a commodity or service.'[459] Further, Hexner notices that the 'Co-ordinated marketing behavior is naturally the opposite of strong rivalry.' With a reservation that the 'active competition' would not automatically emerge in all circumstances in the absence of cartels, Hexner affirms that the restricting competition is, indeed, a fundamental feature of any cartel. The 'co-ordination of marketing behavior', then, may affect all aspects of production of commodities or services concerned, such as extraction, processing, transport and merchandising.[460]

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[458] Frans van Waarden,"Emergence and Development of Business Interest Associations. An Example from the Netherlands," *Organization Studies* 13, no. 4 (1992): 521.
[459] Ervin Hexner, *International Cartels* (Chapel Hill: University of North Carolina Press, 1946), 24.
[460] Ibidem, 31.

As the present study follows a regional approach, taking the glass-producing region of Charleroi (as well as the adjacent parts of the Centre region) as both a geographical as well as a conceptual framework (industrial districts theory), the regional-level institutions will be discussed first. Of these, the *Association* will receive by far the most attention. If we are to answer the question of what truly set the glass-production region of Charleroi apart, assuring its success, the emphasis on the *Association* is justified. Moreover, the source situation is favourable, as a private archive of Mr Frédéric Gobbe containing the entire proceedings of the *Association* from its establishment in 1848 could be consulted (see the chapter on sources in the general introduction), and provided a wealth of information not only on the institutional history of the *Association* itself, but on many other aspects of the window-glass industry, ranging from technological innovation to the provision of raw materials and fuel.

First, the regional organisation (chamber of commerce) will be discussed as far as sources allow. After this, more attention will be dedicated to the sectoral business organisation (*Association des Maîtres de Verreries*). Taking the regional context as the reference, the national-level institutions will be regarded through the interactions with the *Association* mostly, while more general context will be provided as well.

Chambers of commerce

The chambers of commerce were (and still are) associations that act as representatives of business of a specific city, region or an entire country. In general, their goal is to advocate business interests in various ways. They often act as consultative bodies, engaging in negotiations with public authorities and informing them on various business-related matters. The first 'modern' chambers of commerce in present-day Belgium were established in 1802. They were maintained during the 'Dutch period' of the United Kingdom of the Netherlands. After the independence of 1830, the Belgian Government recognised the importance of these institutions. A new legal framework for their functioning was created by the law of 16 March 1841. Thereby, the chambers of commerce were defined as 'official institutions' that served (and were controlled by) the government. The composition (the members) of the chambers was intended to represent the most important sectors of industry and commerce of the chamber's locality. According to the 1841 law, the chambers had to inform and advise the government on matters relevant to economic activities. They were also involved in the organisation of world fairs and other industrial exhibitions, the development of transport infrastructure and other relevant matters.[461]

However, the importance of these chambers started to decline after 1860 approximately. According to the view found in older literature, they became too rigid and no longer adequately served entrepreneurs' needs. Therefore, these 'official' chambers of commerce were abolished by the law of 11 June 1875. However, more recent research by Guy Vanthemsche (2004) shows that the entrepreneurial elites were, in fact, satisfied with these 'official' chambers, and were not in favour of their suppression. The 'official' chambers were

[461] Chantal Vancoppenolle, "De Kamers van Koophandel in België (1830 tot heden). Van officiële adviesorganen tot autonome dienstverlenende werkgeversorganisaties," *NEHA-Jaarboek voor economische, bedrijfs- en techniekgeschiedenis* 59 (1996): 77-94; Guy Vanthemsche, "De geschiedenis van de Belgische werkgeversorganisaties. Ankerpunten en onderzoekshorizonten," *NEHA-Bulletin* 9, no. 1 (1995): 3-20.

more likely suppressed as a result of the political struggles between the Liberals and Catholics, but discussing these matters would go beyond the scope of this study.[462]

At the moment of their suppression, there were 21 'official' chambers of commerce. All of them were re-established already in 1875 or shortly afterwards as 'free' (that is, independent and voluntary) business associations, quite often with the same members as the old 'official' chambers, as was the case for the Charleroi Chamber of Commerce. The new 'free' chambers had much more autonomy when compared to the old 'official' ones. Their function did not change dramatically after 1875. In general, they strove for the economic development of their localities. They engaged in questions such as the development of infrastructure, vocational training, and the organisation of industrial exhibitions. [463]

Charleroi Chamber of Commerce

Despite being an important industrial centre already from the 17th and 18th centuries onwards, Charleroi lagged behind other localities with respect to the establishment of a local chamber of commerce. It was only created by a royal decree of 19 May 1827 as *Chambre de Commerce et des Fabriques de Charleroi*. The number of members at the moment of establishment amounted to nine, the minimal size. However, it was extended to twelve in 1850, 15 in 1860 and 18 in 1865, undoubtedly reflecting the industrial development of the Charleroi region.[464] After the suppression of the old 'official' chamber of commerce of Charleroi, a new 'free' chamber was re-established in 1878 as the *Chambre d'Industrie, d'Agriculture et de Commerce de Charleroi*.[465]

Unfortunately, the source situation does not allow to study the role of the Charleroi Chamber of Commerce in the development of the window-glass industry. The published sources, being the reports of the chambers of commerce, include interesting 'general' information on the situation of the glass industry (used elsewhere in this thesis), yet provide little (if any) information on the internal workings of the chamber. The unpublished documents of the 'official' Charleroi Chamber of Commerce for the period 1827-1875 are preserved within the State Archives of Mons. However, the way these archives are arranged makes it impossible to conduct a systematic search for documents related to the glass industry. Most files are arranged chronologically (for instance, correspondence) or even as 'various cases' without any further description in the inventory. There is only one file related to the glass industry specifically, but it did not contain much relevant information.[466]

Nevertheless, it is still possible to form an idea of the degree to which the window-glass industry was represented within the chamber. As mentioned, the composition of chambers

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[462] Guy Vanthemsche, "Intérêts patronaux entre sphère publique et sphère privée : la suppression des Chambres de Commerce officielles en Belgique (1875)," *Revue Belge de Philologie et d'Histoire* 34, no. 1 (2004): 5-47.
[463] Vancoppenolle, "De Kamers van Koophandel in België (1830 tot heden)," 77-94; Vanthemsche, "De geschiedenis van de Belgische werkgeversorganisaties," 3-20; Vanthemsche, "Intérêts patronaux entre sphère publique et sphère privée," 5-47.
[464] Stauder, *La Chambre de Commerce et des Fabriques de Charleroi,* 9, 25.
[465] Ibidem, p. 41
[466] State Archives of Belgium. Finding aid. *Chambre de Commerce de Charleroi – inventaire des archives des chambres de commerce* (Brussels: State Archives of Belgium, n.d.)

of commerce was intended to represent industries of the location where it was situated more or less, although this had not always been the case in reality. During its period of existence (1827-1875), the 'official' chamber of commerce had five presidents. Two of these were glass manufacturers: Jules Frison (active between 9 July 1833 and 3 February 1849) and Dominique Jonet (active between 13 February 1871 and 11 February 1872).[467] Of the 49 years of its existence, the 'official' Chamber of Commerce was presided over by a representative of the window-glass industry for about 16 years.

Upon its (re)establishment in 1878, the 'free' Chamber of Commerce formed 17 industry-specific 'special committees'. The number of members of each of the 'special committees' was proportional to the importance of this industry. The 44 members of all 17 'special committees' formed the general counsel of the Chamber of Commerce. The four largest 'special committees' had four members. These were the committees of collieries, metallurgy, [window] glass, and commerce. Apart from these, there were two three-member committees and six two-member committees. It appears therefore that the window-glass industry was represented as one of the major industries within the chamber of commerce. An even more important clue is mentioned by Fred Stauder, as the window-glass special committee within the chamber of commerce actually coincided with the *Comité verrier* founded in 1848 (that is, the *Association des Maîtres de Verreries*; see next paragraph).[468] While the proceedings of the *Association* do not mention this explicitly, nor do they contradict it.

All in all, even if we do not know exactly how the Chamber of Commerce functioned and how it supported the development of the window-glass industry, we can assume with a degree of certainty that the window-glass industry had a significant influence within this body, as it was well-represented. Moreover, the fact that the Chamber of Commerce was literally interlocked with the *Association des Maîtres de Verreries* (as the *Comité Verrier* was represented within the Chamber of Commerce) provides us with a curious example of two connected institutions: one region-specific (the Chamber of Commerce) and one industry-specific (the *Association*). Here, 'interlocking' refers to the situation (primarily in a corporate context) whereby members of a board of directors (or similar organs) serve on boards of multiple firms.[469] In our case, the same representatives served within the *Association* as well as the Chamber of Commerce.

Last but not least, the importance of a chamber of commerce as a governing body for an entire industrial district, encompassing various industries, is attested by multiple demands for the creation of a chamber of commerce for the Centre region. During the era of 'official' chambers of commerce, multiple attempts to this end were undertaken by Abel Warocqué, a prominent collieries entrepreneur of Morlanwelz from 1860 on. Shortly before the abolition of 'official' chambers of commerce in 1875, Léon Houtart, a prominent industrialist and owner of several glass factories in the Centre region and a Member of Parliament (liberal), pleaded in parliament for the establishment of a new chamber of commerce in the Centre. In his view, while being a well-developed industrial region already, the Centre suffered a 'significant disadvantage' (*désavantage marquant*) because it did not possess its own

[467] Stauder, *La Chambre de Commerce et des Fabriques de Charleroi*, 37.
[468] Ibidem, 41.
[469] John Scott, *Corporate Business and Capitalist Classes* (Oxford: Oxford University Press, 1997), 7.

representational organisation, as it was divided between the chambers of commerce of Charleroi and Mons.[470]

This instance illustrates several important points. First of all, it makes clear that (at least some) industrialists regarded the 'official' chambers of commerce as useful for the industry, even in the last years of their existence. This supports Vanthemsche's hypothesis that the industrial elites regarded the 'official' chambers of commerce as useful and did not wish for their abolition.[471] Second, it shows that the industrialists from the Centre considered that this region had its own identity as an industrial district, distinct from those of Charleroi and Mons. Nevertheless, it could not achieve its own institutional autonomy, because it could not establish its own chamber of commerce. Therefore, it can be assumed that chambers of commerce were regarded as important (or even defining) institutions for their industrial districts.

Association des Maîtres de Verreries

As already mentioned, the *Association des Maîtres de Verreries* was the most distinct, if not most important of all the governance bodies and institutions related to the Belgian window-glass industry as well as the Charleroi region. The national institutions were, obviously, not exclusive to any region. Therefore, they alone cannot explain the success of a specific region. The chambers of commerce were specific for every region, yet they were all based on the same model, making them less exclusive than the specific region- and industry-based organisations.

Therefore, if we are to explain how the glass-producing industrial district functioned, how its success can be explained, and what set it apart, we must direct our attention to the *Association* primarily, while, obviously, still looking at the interactions of the *Association* with other institutions on the regional, national, and even international level. The *Association* presents us with an example of what we will call a business owners' association, as this term seems to be more general and 'neutral' than other possible alternatives (employers' organisation, trade association, business association and so forth).

The structure of this section is as follows. First, a brief theoretical and historical introduction to the business owners' associations will be provided. Then, a brief institutional history of the *Association* itself will be presented. In the subsequent subchapters, the main functions and activities of the *Association* will be analysed. A great deal of attention will go to the coordination of production and trade, as this seems to have been the most important of the *Association*'s functions. International engagement related to the gathering of information abroad, contacts with foreign colleagues and some other activities will be discussed as well. However, many other functions and activities are discussed elsewhere in this thesis in relation to other topics. For instance, the relationship between the *Association* and the Belgian government in the context of international trade and promotion is discussed later in this part, as well as the *Association*'s engagement with transport and logistics, and the procurement of fuel and raw materials. The role of the *Association* in the development of

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470 Stauder, *La Chambre de Commerce et des Fabriques de Charleroi*, 34-35.
471 Vanthemsche, "Intérêts patronaux entre sphère publique et sphère privée," 39-41.

technological innovation and relationships with the labour movement will be discussed in Part 3, Chapter 3.2.

Business interest associations

The *Association des maîtres de verreries* was one of the sectoral (industry-specific, as opposed to the chambers of commerce) business interest associations (BIAs) that emerged in Belgium in the course of the 19th century.

In general, sectoral BIAs emerged later than chambers of commerce. An article by Frans van Waarden, based on a quantitative study of Dutch BIAs, provides some interesting insights in this respect.[472] In the Netherlands, BIAs started to appear after 1870. Crises often played a stimulating role in this process. In particular, the State interventionism in crisis situations was often regarded as a threat by entrepreneurs, who formed BIAs to counter it. Among other things, opposing the labour movement (strikes, wage demands) was an impetus for the formation of (Dutch) BIAs. Quite often, the formation of BIAs was also a reaction to the emergence of other associations, such as the associations of workers (labour unions), suppliers, customers and so forth. The formation of a BIA was facilitated if the industry in question showed strong differentiation in many (sub)sectors and branches, that is, many small and relatively homogeneous groups. Moreover, regionally concentrated industries tended to develop stronger BIAs, as they could rely on stronger interpersonal ties between members due to close personal acquaintance and even shared local identity.[473]

In general, most BIAs evolved from representative to control organisations in the course of their history. This means that they became more formalised (increasing explicit regulation instead of ad hoc arrangements), centralised (for example, forming an executive committee within the BIA), professionalised (for example, BIAs started to employ a paid secretary) and more integrated in larger networks (participation in national business federations, cooperation with state agencies and even with labour unions).[474] While the relevance of these observations by van Waarden certainly goes beyond the purely Dutch case (and is, therefore, relevant for Belgium as well), some particularities of the Dutch situation should be kept in mind. In particular, the Netherlands were relatively late to industrialise, as by and large this started only after 1870, which may explain the late appearance of Dutch BIAs.

In Belgium, the first BIAs emerged much earlier. Already in 1831, the *Association Charbonnière du Bassin de Charleroi* was formed, followed by the *Association des Maîtres de Forge de Charleroi* and the *Comité Houiller du Centre* around 1840-1841. In 1865, the *Association Houillère du Couchant de Mons* was established in 1868, followed by the *Union des Charbonnages, Mines et Usines Métallurgiques de la province de Liège* in 1868. As it appears, these BIAs were located in the primary centres of Belgian industrialisation (Mons, Centre, Charleroi, Liège), and united enterprises belonging to the key sectors of Belgian industry at that time (coal mining, metallurgy). This is hardly a surprising conclusion, of course. BIAs in other industries and regions, such as textiles in Ghent and Verviers or building

[472] van Waarden, "Emergence and Development of Business Interest Associations," 521-562.
[473] Ibidem, 527-534.
[474] Ibidem, 535-539.

contractors in Antwerp, Brussels and Liège, followed somewhat later after 1870.[475] It is interesting to note that the combination ban, forbidding all kinds of professional coalitions and having its root in the 1791 Le Chapelier law, was only abolished in 1866. Therefore, all BIAs established before this date were, technically, illegal. However, the coalition ban targeted labour unions primarily.[476] Therefore, the assumptions made in older literature, that the first BIAs emerged from the 1870s-1880s on as a reaction to the labour movement, are untrue, as shown by Vanthemsche in his article (1995).[477] Unlike the pre-1875 chambers of commerce, the BIAs were 'free' (i.e. voluntary) organisations. According to Vanthemsche, entrepreneurs developed a kind of double strategy, relying on the chambers of commerce to promote the interests of their locality, and on the BIAs to promote the interests of their industry. Hence, both types of organisations had a symbiotic rather than antagonist relationship.

The first BIAs were regional, as shown by the aforementioned examples. From approximately 1870s on, the first national BIAs started to emerge; for instance the *Comité Général de l'Industrie Charbonnière Belge* (coal mining) in 1870 or the national federation of building contractors, first established in 1881 and known under the name *Fédération Nationale Belge du Bâtiment et des Travaux Publics* from 1914 on. Lastly, the first national interprofessional association was established in 1895 as the *Comité Central du Travail Industriel de Belgique*. In 1913, the name was changed to *Comité Central Industriel de Belgique* (CCI).[478]

Institutional history of the Association

The *Comité verrier*, as it was first called, was established on 28 November 1848. During its first decades, it existed as an organisation without any legal statutes. It received a legal status as the *Association des maîtres de verreries belges* in 1873.

At the moment of its establishment, the *Comité* (*Association*) united eight members (factories), all from the Charleroi region. All of them were rather modest. The largest manufacturer, the *Verreries de Mariemont* (which belonged to the *Société des Manufactures*) was not among them. Large manufacturers, such as *Société Nationale*, *Bennert & Bivort* and *Jules Frison et Cie* joined later. Unfortunately, the proceedings do not mention members in a systematic way, making it difficult to establish exactly when certain enterprises joined or left the *Association*. However, it is clear that the number of members increased over time. For example, *Bennert & Bivort* joined in 1849. The *Comité* (*Association*) had 15 members in 1853, 20 in 1871 and 53 in 1874. Hence, by the 1870s it united almost the entire Belgian window-glass industry.[479]

The *Association* clearly limited its scope to the blown window-glass industry (as opposed to the cast and polished plate glass or mirror glass, known as 'glace'). On one occasion in 1874, the *Association* received a letter from O. Houtart asking whether the factories of cast glass

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[475] Vanthemsche, "De geschiedenis van de Belgische werkgeversorganisaties," 3-7.
[476] Vanthemsche, *De paradoxen van de Staat,* 99.
[477] Vanthemsche, "De geschiedenis van de Belgische werkgeversorganisaties," 5.
[478] Ibidem, p. 13-14.
[479] De Leener, *L'organisation syndicale des chefs d'industrie,* Vol. 1 les faits, 227-241; Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 369-378; Darquennes and Gobbe, *Les verriers Schmidt*, 166-167.

could join the *Association* as well. The *Association* responded that it did not see any advantages to this and returned the question by asking Houtart for the possible advantages. As no answer was ever received (or, at least, not recorded in the proceedings), and no cast-glass factory ever joined the *Association,* it seems Houtart did not even try to convince the *Association* of the 'advantages' that the cast-glass factories could provide to the organisation.[480]

The *Association* held its last assembly on 18 July 1927 and was liquidated legally on 28 November 1932.[481]

Centralisation and professionalisation of the *Association*

The adaptation of a legal statute by the Association in 1873 was an important step towards the centralisation and professionalisation of the organisation, as defined by van Waarden.

According to the statues, adopted on 31 May 1873, the *Association* introduced a *comité* of seven members. Its main functions were the preparation of general assemblies and the execution of decisions adopted by general assemblies.[482] The 'new' meaning of the word *comité* should not be confused with the old. Before 1873, the *comité* referred to the entire BIA, while afterwards it signified the executive committee of the BIA, while the BIA itself changed its name to the *Association*. The emergence of an executive committee is a sign of growing centralisation within the organisation.

As noted by van Waarden, the employment of professional secretary was an important step towards the professionalisation of a BIA. Indeed, a professional impartial secretary who acted in the general interests of the entire group could enjoy more credibility than a member acting as a secretary, who might be tempted to act in his own rather than in the general interest.[483] Before 1873, one of the members of the *Comité* (*Association*) or his representative acted as a secretary. Apparently, the first secretary had been Loral (no first name mentioned) of the firm Martin Denuite. In 1854, he was replaced by Casimir Lambert, a prominent glass manufacturer and by no means an 'independent' secretary.[484]

The statutes of 1873 mention the duties of secretary, yet do not state explicitly whether he ought to be independent and professional (i.e. not one of the *Association*'s members).[485] Nevertheless, it can be attested with relative certainty that the *Association* started to employ a professional or semi-professional secretary circa 1872-1873 in the person of Charles van der Elst. Although the proceedings do not systematically mention the secretaries for a long time, he himself referred to his 23-year service for the Association on 15 March 1895, when he decided to announce his resignation from the Secretary position.[486] However, on 17 March the same year, Vander Elst announced that he would postpone his resignation 'for a

[480] Private archive Gobbe, Association, Brouillons I, Séance 7 avril 1874
[481] Darquennes and Gobbe, *Les verriers Schmidt,* 166.
[482] Private archive Gobbe, Association, Originaux C, Statutes Association, Séance 31 mai 1873
[483] van Waarden, "Emergence and Development of Business Interest Associations," 546.
[484] Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 370.
[485] Private archive Gobbe, Association, Originaux C, Statutes Association, Séance 31 mai 1873
[486] Private archive Gobbe, Association, Originaux C, Assemblée Générale 15 mars 1895

few years'.[487] It is difficult to judge with certainty how professional and 'independent' he was, but his name never appeared in connection with the glass industry *stricto sensu* in the proceedings or other sources, making it quite plausible to regard him as at least a semi-professional and independent secretary.[488]

Cooperation with other business interest organisations

As will be discussed further in the section on transport and tariffs, the *Association* joined forces with business interest organisations from other sectors (metallurgy mostly) on several occasions in order to resolve practical problems. In 1910, the *Association des Maîtres de Forges* (BIA of metallurgists) proposed to the *Association des Maîtres de Verreries* to establish an 'industrial stock exchange' (*bourse industrielle*) in Charleroi within the *Passage de la bourse*. The *Association* supported this proposition.[489]

As already mentioned, according to Stauder the *Association*'s *comité* functioned as one of the 'special committees' of the post-1878 'free' Charleroi Chamber of Commerce. There is some inconsistency here, as the *Association*'s *comité* had seven members, while the Chamber of Commerce 'special committee' had four. Therefore, the *Association*'s *comité* could not have been represented within the 'special committee' of the chamber of commerce. At any rate, given the fact that the window-glass industry was well represented within the Chamber of Commerce, there is little doubt that there was a degree of interlocking between the two organisations. This reminds us of the 'double strategy' of entrepreneurs, as described by Vanthemsche.[490]

The political ideology of the *Association*

As a very export-oriented industry, the window-glass industry strongly opposed any kind of protectionism. It generally adhered to liberal and non-interventionist views, in particular considering international trade. On some occasions, these views were expressed quite explicitly in public. For example, when preparing their exposition for the 1867 Paris World Fair, the *Association* decided to embellish it with two busts, one of the Belgian liberal politician Charles de Brouckère, another of a certain Masson (exact identity could not be retrieved), accompanied by the inscription *Liberté Commerciale*.[491]

In some instances, the *Association* could translate its political and ideological views directly thanks to representatives in the Parliament. For instance, Casimir Lambert acted as a liberal Member of Parliament between 1874 and 1890.[492] According to the eulogy in his memory, delivered by the *Association's* president Émile Fourcault in 1896, Lambert engaged in an 'energetic campaign, as a collaborator of Cor. Vandermaeren, in favour of free trade (*libre-échange*), the only regime that conforms to the Belgian national interests'.[493] On another

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[487] Private archive Gobbe, Association, Originaux C, Assemblée Générale 17 octobre 1895
[488] Private archive Gobbe, Association, Originaux C, Assemblée Générale 30 novembre 1896
[489] Private archive Gobbe, Association, Originaux D, Assemblée Générale 28 février 1910
[490] Vanthemsche, "De geschiedenis van de Belgische werkgeversorganisaties," 6.
[491] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1867
[492] Kurgan-Van Hentenryk, Jaumain and Montes, eds. *Dictionnaire des patrons en Belgique,* 406-407.
[493] Private archive Gobbe, Association, Originaux C, Assemblée Générale 30 novembre 1896

occasion in 1894, the *Association* reaffirmed its liberal stance by sending a delegation to a banquet in honour of Louis Strauss, an economist, diplomat and liberal politician from Antwerp, heralded by the *Association* itself as a 'champion of commercial liberty' (*champion de la liberté commerciale*).[494]

Moreover, the *Association* participated in overarching business interest organisations that adhered to liberal principles. For instance, in 1893, the *Association* decided to join the *Fédération des Associations Commerciales*, hoping to find within this organisation 'a force to oppose protectionist doctrines'.[495] Later, it joined the *Comité central du travail industriel*. As the *Association* formulated it itself in 1897, 'these institutions fight rigorously against interventionalist theories'.[496] It may be assumed that by participating in such organisations, the *Association* could engage in lobby work on economic matters, or at least stay informed. For instance, the *Comité central du travail industriel* championed free trade and opposed 'exaggerated' social legislation and all kinds of government interference.[497] From another point of view, this attests to the incorporation of the *Association* into the broader networks. All in all, the *Association* generally followed the same development path as described by van Waarden (centralisation, professionalisation, inclusion into broader networks).

Coordination of production and trade by the Association

Broadly speaking, the management of conflicts and cooperation is one of the core functions of BIAs such as the *Association*. The following paragraphs will focus on the (mostly formal) arrangements of these matters by the *Association*, as any mentions of informal and semi-formal arrangements in sources are extremely scarce. After a brief introduction, a theoretical framework will be provided, followed by a more detailed discussion of various types of formal arrangements.

Informal and semi-formal arrangements

To begin with, cooperation could be achieved by informal and semi-informal arrangements and agreements. It is impossible to know exactly how widespread such arrangements were, exactly because of their informal nature. Yet the proceedings contain several mentions of such informal and semi-formal cooperation mechanisms. For instance, on one occasion in 1852, it was remarked that some factories hadn't had orders for quite some time, while others had so many orders that they couldn't keep up. This situation was attributed to the clandestine discounts offered to clients by some manufacturers. It was announced that such practices were against agreements and honour.[498] This case indicates that, despite generally individualistic attitudes within the community of glass manufacturers, there were still some informal and semi-formal 'rules of good behaviour and honour' among the members, aimed

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[494] Private archive Gobbe, Association, Originaux C, Assemblée Générale 17 décembre 1894
[495] Private archive Gobbe, Association, Originaux C, Assemblée Générale 11 août 1893
[496] Private archive Gobbe, Association, Originaux C, Assemblée Générale 19 novembre 1897
[497] Guy Vanthemsche, "De werkgeversorganisaties," In: *Bronnen voor de studie van het hedendaagse België, 19^e^-21^e^ eeuw*, 2nd rev. ed., eds. Patricia Van den Eeckhout and Guy Vanthemsche (Brussels: Koninklijke Commissie voor Geschiedenis — Commission Royale d'Histoire 2009), 864.
[498] Private archive Gobbe, Association, Originaux A, Séance 2 avril 1852

at maintaining 'fair' competition. Unfortunately, no further mentions of such rules of honour are to be found in the proceedings, perhaps precisely because of their informal nature.

Formal arrangements

Much more information was recorded about the formal arrangements, in particular concerning the coordination of production (and trade) among various manufacturers, understood broadly. Indeed, such arrangements appear as the core activity of the *Association* from the proceedings. This coordination can be divided into various subfields, such as the fixing of standard prices and tariffs, the standardisation of properties of products, the collective 'human resources management' (organisation and control of labour, struggle against and bargaining with labour unions), among other things.

The following paragraphs focus on the coordination of production and trade in the most direct way, that is, the collective arrangements with regard to the regulation and limitation of production capacity and trade arrangements. In some instances, the way in which the *Association* managed these issues is quite similar to cartel agreements. In some cases, these arrangements encompassed other functions as well, such as 'human resources management'. While the proceedings mention many formal arrangements that were discussed and adopted over the years, information on the way these arrangements were enforced (including sanctions against offenders) is absent in most cases.

Other interesting topics also appeared in the context of coordination of production and trade. In particular, the ideological issues that emerged on some occasions. As already noted, the *Association* generally adhered to the liberal, non-interventionist view. Yet, this stance conflicted with the (proposed) measures towards more coordination between members. As already mentioned in the introduction to this part, the simple dichotomy of collective vs individual behaviour is not sufficient. Therefore, special attention will be paid to the specific characteristics of 'dissident firms' (those that opposed collective measures most often).

Theoretical background

Writing on the Belgian BIAs in 1909 (or *syndicats industriels* as he called them), Georges De Leener, a professor of economics at Brussels university at the time, distinguished a number of mechanisms for the coordination of production and trade by the BIAs (only the most relevant for the present case are mentioned). These mechanisms were grouped by De Leener into three categories, the sales syndicates (*syndicats de vente*), the purchase syndicates (*syndicats d'achat*) and employment syndicates (*syndicats d'emploiement*).

The sales syndicates considered sales as well as production. In other words, these mechanisms regulated the way BIAs offered their products to the market. Within the sales syndicates category, De Leener distinguished the following mechanisms:

- Coordination of sales conditions: these included the sales conditions, tariffs and prices
- Distribution of sales: by distributing ('dividing') clients between members, BIAs tended to limit or eliminate competition between members

- Limitation of production: similarly to the previous, this measure limited or prevented 'unnecessary' competition between members
- Common sales whereby participants sold their products through one common sales office, often called *comptoir de vente*, or by a similar means

The purchase syndicates employed similar mechanisms to those of the sales syndicates, such as the aforementioned coordination of prices, the formation of centralised purchase offices and the like. However, as noted by De Leener, the purchase syndicates were very rare compared to the sales syndicates, in Belgium as well as abroad. The reason is rather straightforward. Both types of syndicates relied on monopolies. Yet, a 'purchase monopoly' was much harder to establish than a sales monopoly. For example, if all Belgian consumers of a certain product decided to create a 'purchase monopoly' by centralising their purchases though a centralised office, the manufacturers of this product could sell their product abroad. In fact, the purchase syndicates could only function in the situation of a monopsony, which is generally not to be expected in an open market economy.

Lastly, the employment syndicates considered the relationship with labour. The mechanisms within this category included the fixation and imposition of uniform employment and labour conditions, the fixing of wages as well as the 'resistance to workers' demands' (labour unions).[499]

It is quite apparent that the measures as summed up by De Leener, and the sales syndicates in particular, are more reminiscent of cartels than of BIAs in the present-day meaning. As it appears to me, no clear-cut distinction between cartels and BIAs was acknowledged at that time. At any rate, the functions of the *Association* fit into both categories, as it engaged in the activities typical of present-day BIAs, such as lobbying and distributing information, as well as those nowadays regarded as typical of cartels, such as price agreements. Imposing present-day concepts and clear-cut distinctions between cartels and BIAs would thus be anachronistic in my opinion.

This framework will be used for the analysis of the *Association's* activities concerning better coordination between participants, with sections on purchase syndicates, employment syndicates and subcategories of sales syndicates (coordination of sales conditions, distribution of sales and limitation of production and common sales). The aforementioned terms were not employed by the *Association* itself when referring to various arrangements it undertook in order to assure better coordination. Rather, the *Association* employed terms such as *chômage*, *entente*, *mutualité,* and *convention*. Below, the application of these mechanisms will be surveyed chronologically, while certain analytical conclusions will follow at the end of the chapter. *Chômage*, meaning the coordinated interruption of work in order to reduce production (verb: *chômer*), was the most common type of coordinated arrangement. It clearly corresponds to the limitation of the production mechanism as mentioned by De Leener, and thus to the broader category of sales syndicates. Quite often, *chômage* was discussed simultaneously with arrangements for the coordination of trade, most often designated as *convention*, whereby both types of arrangement were regarded as

[499] De Leener, *L'organisation syndicale des chefs d'industrie*, Vol. 2 la théorie, 285-379.

alternatives. The *convention* corresponds to De Leener's distribution of sales and common sales, still within the sales syndicates category.

It is impossible to regard both types of arrangements (*chômage* and *conventions*) separately. As for *entente* and *mutualité*, the meaning of these terms seems to have been rather variable, depending on specific arrangements.

The *Association* as a purchase syndicate

The *Association's* proceedings did not contain any traces of true purchase syndicates. However, occasionally, arrangements for group purchases and other measures regarding the provision of fuel and raw materials were concluded. While not purchase syndicates as defined by De Leener, since they could by no means achieve any kind of a 'purchase monopoly', these arrangements are nevertheless worth discussing here, as they represent the *Association's* agency (as a collective agency) in the matters of provision of fuel and raw materials. Yet, as will be shown in the following, the individual agency of firms remained more important in this context, albeit not without exceptions.

Moreover, the management of the provision of fuel and raw materials is important from the viewpoint of the four-quadrant model of the industrial districts (Popp, Toms and Wilson, 2006). As part of the 'resource base' (narrow or extensive), the availability of the raw materials and fuel is one of the defining factors of the industrial district's structure. Hence, the provision problems mentioned in the *Association*'s proceedings signal whether these resources were limited or extensive, while the measures undertaken by the *Association* as a collective actor illustrate the active role the *Association* played in the shaping of the district.

Fuel

Except for a few instances of trial purchase, individual members seem to have organised coal purchases on an individual basis, albeit with a certain 'assistance' on the part of the *Association*, which conducted research on the possible (foreign) markets for coal, as mentioned in the chapter on the sources of raw materials. In 1867, the opportunity for a collective purchase of coal, modelled after the arrangement for the collective purchase of sulphate, was proposed by Léopold de Dorlodot-fils at the gathering of 23 September. During the discussion of this topic it was mentioned that such an arrangement could be an efficient one, on condition that all members 'group themselves' to this end. Yet the execution of such an arrangement was described as 'generally difficult to realise'.[500] On 16 December of the same year, the question was discussed again. On this occasion, Houtard-Roullier expressed the opinion that the collective purchase of fuel (*acheter le combustible en convention*) could be advantageous for the provision of coal from Ruhr, Mons (Borinage) and Liège, yet for the coal from Charleroi and Centre, purchase on an individual basis was regarded as more advantageous.[501] Despite the potential advantages of collective purchase at least on some markets, the matter was not followed up. The possibility of the collective purchasing of coal was brought up again in 1870, whereby the formation of a section committee, not unlike the already active *comité de sulphates*, was proposed. It was decided to form a special

[500] Private archive Gobbe, Association, Originaux A, Séance 23 septembre 1867
[501] Private archive Gobbe, Association, Originaux A, Séance 16 décembre 1867

commission for the study of this question, yet there is no further mention of it in later proceedings.[502] The possibility of a group purchase of coal by the *Association* for all members in order to lower the price was proposed but rejected by the assembly on 31 May 1873.[503]

On one occasion in 1889, a group purchase of coal along the same lines as for sulphate was proposed, but rejected, which indicates that manufacturers continued to organise their supply on an individual basis.[504]

Interestingly, in 1896, Henri Lambert, one of the *Association*'s prominent members, remarked that it was 'of utility for the Belgian window-glass industry' to keep French coal suppliers in competition with their Belgian counterparts from Mons. While this remark can be interpreted as a sign of a deliberate commercial policy (to set coal suppliers against each other, clearly in order to get lower prices), the possibility of a collective purchase arrangement for coal (*entente pour l'achat de charbons*) in Pas-de-Calais was rejected during the same meeting, making it unlikely to suppose that any kind of coordinated, deliberate commercial policy had been followed by the *Association* previously.[505] As had been the case so often previously, the awareness of a need for closer cooperation within the *Association* collided with the individualistic attitudes of its members.

<u>Sodium sulphate</u>

Sodium sulphate proved to be the most 'problematic' of raw materials, because the production levels of the Belgian sodium factories proved insufficient for the Belgian window-glass industry. The *Association* played an active role in this matter, engaging in negotiations with the Belgian sodium manufacturers and assuring provision of foreign (primarily British) sulphate, in particular in 1856 and 1864-1865.

The first series of actions and negotiations conducted by the *Association* began on 31 May 1856, when a commission consisting of Jonet, Gorinflot and Casimir-Lambert-fils had been set up by the *Association* with the purpose of requesting 'free entry' (most likely, import without import duties) at the Ministry of Finance.[506] By July 1856, the situation had not yet improved. According to the proceedings, the prices demanded by the sodium manufacturers remained (too) high. Therefore, the *Association* still demanded 'free entry' of sodium from abroad.[507] It is not entirely clear which manufacturers (domestic or foreign) they were referring to, but logic suggests that the problem lay with the Belgian manufacturers. In order to settle the issue, a whole series of negotiations were conducted between the *Association* and the Belgian sodium manufacturers.

At first, the negotiations between the *Association* and Mr Federmeyer, director of the sodium factory Risles (Vedrin) near Namur, were conducted on 29 July 1856. There, Mr Federmeyer informed the members present that he was not in a position to comply with the agreements

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502 Private archive Gobbe, Association, Originaux A, Séance 21 février 1870
503 Private archive Gobbe, Association, Originaux C, Séance 31 mai 1873
504 Private archive Gobbe, Association, Brouillons II, Séance du 14 janvier 1889
505 Private archive Gobbe, Association, Originaux C, Assemblée Générale 9 mars 1896
506 Private archive Gobbe, Association, Originaux A, Séance 31 mai 1856
507 Private archive Gobbe, Association, Originaux A, Séance 5 juillet 1856

(most probably, supply contracts) that he had concluded with several members previously, as he had to reduce the production of sodium sulphate considerably due to a new 'prohibition' that had been imposed on him. Unfortunately, no details on this 'prohibition' were given. Presumably, it was some kind of government measure.

Furthermore, the *Association* distinguished two principal ways to resolve the sulphate problem. The first was to support the Belgian sodium factories, the second to rally for the 'free entry' of the raw material. Hence the dilemma presented a choice between protectionism and free trade. Responding to this, Mr Federmeyer stated that he would accept 'free entry' if he himself were relieved of all duties. In the present circumstances, he would accept import duties of 1.50 Belgian franc per 100 kg of sulphate, as he judged it to be 'protective enough'. Yet this was his personal opinion. In order to discuss the matter further, it was decided to organise negotiations with the representatives of all Belgian sodium factories.[508]

The negotiations between the *Association* and most, if not all, Belgian sodium factories took place on 31 July 1856. Here, the question of import duties was discussed, albeit without resulting in a clear conclusion. Concluding the negotiations, it was decided to send a deputation to the Ministries of Internal Affairs and Finance with a dual goal of allowing the putting back into operation of the sulphate ovens that had been inactive due to the 'prohibition', and of setting the import duties at 2.00 Belgian franc per 100 kg.[509] Shortly after the aforementioned negotiations, on 14 August 1856, the *Association* decided to go to Brussels *en masse* in order to submit the petition for the 'free entry' of sulphate to the King himself, as the Ministers of Internal Affairs and Finance showed little goodwill.[510] Whether or not this deputation actually took place is not known, but only two days later, on 16 August, an exceptional permission for the import of 200 ton of sodium sulphate had been granted by a Royal Decree in accordance to with the law on public depots ('sur les entrepôts publics') of 4 March 1846, article 40. Within the *Association*, a commission consisting of Gorinflot, Dethy and C. Lambert had been appointed to divide sulphate among the members.[511]

No satisfactory structural solution to the 'sulphate question' emerged after 1856 despite the aforementioned one-time import permission. Over the course of years and decades, the supply issues, mostly related to excessive import duties, appeared within the *Association's* proceedings time and again.

The 'sulphate problem' reached its zenith around 1864-1865 when apparent shortages forced the *Association* to undertake active steps towards assuring provision of this material to its members. The shortages and rising prices of sulphate had first been reported during the session of 24 October 1864. Unfortunately, no details and exact reasons are provided, but, according to the *Association*, recent sudden price fluctuations had been caused by some importers, traders and manufacturers of sulphate. In order to avoid price fluctuations in the future, the *Association* decided to organise deliveries of sulphate, be it from Belgium or from abroad. In this regard, Achille Andris of the *Verreries de Planche* proposed acquiring English

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[508] Private archive Gobbe, Association, Originaux A, Séance 29 juillet 1856
[509] Private archive Gobbe, Association, Originaux A, Séance 31 juillet 1856
[510] Private archive Gobbe, Association, Originaux A, Séance 14 août 1856
[511] Private archive Gobbe, Association, Originaux A, Séance 20 août 1856

sulphate in Antwerp at the price of 10.50 Belgian franc (most likely, per 100 kg).[512] By 31 October, Dominique Jonet 'had taken action' at various sulphate manufacturers and traders, as well as, specifically, at the importers of English products.[513] In late 1864 and early 1865, these actions started to bear their first fruits. Starting from November 1864, various offers had been discussed within the *Association*. On 2 November 1864, the *Association* accepted an offer of 2,400 ton English sulphate, to be delivered between 1 March 1865 and 1 March 1866. During the same session, various ideas and propositions concerning the organisation of sulphate imports had been discussed.[514]

Despite the aforementioned collective purchase of English sulphate, the supply of this product remained an urgent problem around 1865. On 21 October 1865, a number of prominent members presented to the *Association* reports on their negotiations with domestic and foreign suppliers of sulphate, such as the Belgian firms of Moustier-sur-Sambre and Vedrin as well as some English manufacturers (no specific English firms are mentioned). The proceedings mention this gathering under the heading of *Sulfate-urgence*.[515] Apparently, this urgent gathering resulted in a kind of binding agreement on the purchase of sulphate, yet no specific details of this settlement are provided in the proceedings.

On 24 November 1865, the *Association* decided to extend the aforementioned *convention* of 21 October 1865 (agreement on group purchase of sulphate) until 31 December. As a result, the members were prohibited from buying sulphate without the *Association*'s permission.[516] It seems that the 'sulphate emergency' was more or less resolved by 1865, as no extensive discussions concerning the supply of this material were recorded afterwards. The purchase of sulphate still occurred in an organised, collective way in 1870, as proceedings mention the *comité des sulphates* that dealt with this question.[517] Further propositions for the collective purchase of sulphate were made in 1878 (unclear outcome),[518] 1889 (unclear outcome),[519] 1891 (rejected),[520] and 1896 (rejected).[521]

Other materials

Sand and pottery clay must have been the least problematic of all materials, as they were mentioned only a few times in the *Association's* proceedings. As no instances of collective purchase of these materials were recorded, it can be assumed that they were purchased by manufacturers on an individual basis. A sort of 'coalition for the trade in *planchettes*' was proposed in January 1889 along the same lines as the collective purchase agreement for the sodium sulphate.[522]

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[512] Private archive Gobbe, Association, Originaux A, Séance 24 octobre 1864
[513] Private archive Gobbe, Association, Originaux A, Séance 31 octobre 1864
[514] Private archive Gobbe, Association, Originaux A, Séance 2 novembre 1864
[515] Private archive Gobbe, Association, Originaux A, Séance 21 octobre 1865
[516] Private archive Gobbe, Association, Originaux A, Séance 24 novembre 1865
[517] Private archive Gobbe, Association, Originaux A, Séance 21 février 1870
[518] Private archive Gobbe, Association, Originaux C, Séance 4 novembre 1878
[519] Private archive Gobbe, Association, Brouillons II, Séance du 14 janvier 1889
[520] Private archive Gobbe, Association, Originaux C, Assemblée Générale 29 juin 1891
[521] Private archive Gobbe, Association, Originaux C, Assemblée Générale 21 août 1896, Assemblée Générale 7 septembre 1896
[522] Private archive Gobbe, Association, Brouillons II, Séance du 22 janvier 1889

In conclusion, the *Association* played a limited role as a collective actor in the provision of fuel and raw materials, leaving this to the individual actions of manufacturers in most cases. As concerns the fuel question, the *Association* generally assisted its members by conducting research on the possible fuel markets; however, except for a few 'trial purchases', it did not engage in fuel provision directly, leaving this to individual members themselves. It assumed a much more active role regarding sulphate, however, precisely because the supply of this product appeared to have been much more problematic. We can conclude in this respect that the *Association* was reluctant to interfere when individual firms could acquire the materials needed by their own means, as was the case for coal in most instances; yet it was capable of active engagement when truly needed, as in the case of sulphate, which appears to have been a semi-permanent problem.

As for the four-quadrant model, it appears that most resources were extensive, i.e. easy to acquire in most cases. The only exception was sodium sulphate, which had to be acquired with the *Association*'s assistance, at least during particularly 'difficult moments', such as the 'sulphate emergency'.

The *Association* as an employment syndicate

The role of labour in the context of an industrial district can be regarded in various ways. For analytical purposes, I will make a three-fold distinction.

Labour, especially specialised, was one element of the resource base of the district alongside fuel and raw materials (labour as a resource). According to the four-quadrant model, this resource base could be 'narrow' or 'extensive', which, in turn had consequences for the district's structure. This resource could be managed by a governing body of the district (the *Association* in this case). In my opinion, this management of labour as a resource on the district level by the *Association* comes closest to the concept of an employment syndicate as defined by De Leener. Hence, the following paragraphs will focus on the role of the *Association* as an actor, engaged in the management of labour as a resource rather than in the social struggle between capital and labour, although the social dimension, such as the role of labour unions, cannot be excluded completely. The question to be answered is as follows: was labour a narrow or extensive resource, and what measures were taken by the *Association* to 'manage' this resource in the evolving circumstances?

The pool of specialised labour in itself formed a defining element of the industrial district, being one of Marshallian externalities, and hence one of the main reasons for the concentration of industry within a certain region (labour as an externality). Indeed, one very important topic that appeared in the context of the relationship between the *Association* and labour, was the limits of the industrial district. These 'limits' should be regarded quite literally (that is, geographically) in this case. As will be discussed further, circa 1902-1904 the discussion on what measures to take gave rise to a discussion on who belonged to the district and who did not. This aspect will be discussed in the chapter on externalities.

Finally, labour (especially specialised labour defined by exclusive skills and know-how, such as glassblowing) made up an essential part of the production system alongside technology (labour as part of the production system). While the first aspect (labour as a resource) came to the fore on the district level as it concerned the district as a whole, the role of labour as part of the production system was literally situated on the work floor of an individual factory. It can be best understood in the interaction between the technology (innovation) and the workers' skills. Both aspects (technology and skills) cannot be properly understood as separate concepts and will therefore be discussed together in Part 3 in the context of the evolving production process.

Situation up to the 1880s

The questions of the organisation and control of labour ('human resource management'), broadly interpreted, featured regularly within the *Association*'s proceedings from the first years of its activity on. Yet, during the first three decades of the *Association*'s existence up to 1880s, labourers did not present themselves as an organised collective actor. Moreover, although emigration of glassblowers from Belgium was already being mentioned on a few occasions during this period, it was not yet a major issue. During this period, the focus of *Association* was on the 'collective labour management on the (individual) factory level'. In other words, the *Association* established common arrangements that regulated the relationship between each individual manufacturer and his workers. In particular, much attention was dedicated to the so-called 'making' of workers, which can be interpreted as vocational training of glassblowers and their apprentices (*gamins*) on the work floor. It seems, moreover, that measures to increase control over the labourers on the work floor were also taken by the manufacturers. These topics ('making' of workers and control over workers on the work floor) will be discussed in more detail in Part 3, as they concern labour as a part of a production system rather than labour as a resource. Nevertheless, the fact that the *Association* increasingly intervened in the relationship between individual manufacturers and their workers attests to the collective agency of manufacturers, and is therefore worth highlighting here.

As for the role of labour as a resource, the *Association's* proceedings and other sources provide only scarce and rather indirect indications before the 1880s. That said, it seems that the specialised labour of glassblowers was rather limited, if not a rarity (i.e. a 'narrow resource' according to the four-quadrant model) up to the 1880s. This was already attested by the employment of 'bastard glassblowers' by Léopold de Dorlodot and other manufacturers from the 1820s on.[523] The demand for glassblowers especially grew from approximately 1845 on due to increased production.[524] The shortage of glassblowers was already alluded to by the *Association* in 1853, when a proposition for the establishment of a trade school for glassblowers was discussed, albeit without an outcome.[525] More generally, the emphasis on the 'making' of workers during the period from the establishment of the *Association* points in the same direction as well. Another rather anecdotal piece of evidence for this is to be found within the proceedings of 1881, when the *Association* decided to pay

[523] Autobiographical manuscript by Léopold De Dorlodot, original preserved in the private archives of the De Dorlodot family, reproduced in Marc Belvaux, *La famille (de) Dorlodot. Une famille de verriers et d'industriels de l'Argonne et de la région de Charleroi*, 2 vols. (Brussels: Office généalogique et héraldique de Belgique, 2014), Vol. 1, 288-289.
[524] Poty and Delaet, *Charleroi pays verrier*, 58.
[525] Private archive Gobbe, Association, Originaux A, Séance 18 mai 1853

two thousand Belgian francs for the repatriation of Belgian glassworkers, who wished to return from the United States.[526]

Situation from the 1880s onwards

However, while highly skilled labour seems to have been in short supply (narrow resource) up to 1880 approximately, the situation changed thereafter. As already noted in the introduction to this thesis, the situation became much more unstable, with frequent crises (mostly due to overproduction) followed by periods of resurgence. The glassblowers and *gamins* started to operate as a collective actor for the first time during this period as well, due to the emergence of the organised labour movement. As mentioned previously (see Part 1, Chapter 1.4), the first glassblowers' union, the *Union Verrière*, was established in 1883. This led to multiple strikes and decade-long semi-permanent tensions between employers and workers.[527]

The particular details of these strikes and other labour-capital tensions are beyond the scope of the present study. Instead, attention will be directed to the instances whereby these conflicts reveal some details about the role of labour as a resource. For instance, the possibility of a lockout of glassblowers was discussed by the *Association* in 1883, when it was proposed not to employ new workers beyond those who had already been employed at the time. The outcome of this proposition was unclear, however.[528] At any rate, the proposition of limiting employment is indicative of the abundant rather than scarce labour situation of that time.

One particular question that formed a source of major conflict between the factory owners and glassblowers, and which is quite telling about the role of labour (scarce or abundant), concerned the so-called practice of 'employment of two-for-one'. Here, two workers occupied one employment position, literally replacing each other during various periods of time, like a modern-day job share. This employment system was supported by the *Union Verrière* as it allowed manufacturers to 'employ all glassblowers' (*occuper tous les souffleurs*). Most probably, this refers to the situation of overproduction, whereby the manufacturers reduced their production, causing unemployment among glassblowers. The 'two-for-one' system would allow more workers to be employed, although the exact details of this work-sharing were not recorded explicitly. The issue of 'two-for-one' was discussed on multiple occasions by the *Association*, especially during the 'American crisis' that broke out quite suddenly in February 1884 (see Part 1, Chapter 1.4).[529] At some moments, tensions between the *Association* (which generally opposed the 'two-for-one' arrangement) and the *Union Verrière* (which supported it) became so bad that the *Association* described the actions undertaken by the leaders (of the *Union*) as a 'system of terrorism'.[530] On 21 March 1884, it was formally decided by the *Association*'s general assembly, that the system of 'two-for-one'

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[526] Private archive Gobbe, Association, Originaux C, Séance 17 mai 1881
[527] Poty and Delaet, *Charleroi pays verrier*, 78-98; A. Knotter, "Trade unions and workplace organization," 422-426.
[528] Private archive Gobbe, Association, Brouillons II, Séance 24 septembre 1883
[529] Private archive Gobbe, Association, Originaux C, Exposé de la situation par l'Ass-on des Maîtres de Verreries (undated, inscribed between the Assemblée Générale 26 mars 1884 and Assemblée Générale 31 mars 1884)
[530] Private archive Gobbe, Association, Brouillons II, Séance 12 mars 1884, Séance 17 mars 1884, Séance 21 mars 1884

should be forbidden, except for workers who had already been employed in this manner previously. As was often the case, no details on the enforcement of this measure were recorded, but it seems to have been a matter of general consensus.[531] Only few days later, on 24 March 1884, manufacturers decided to diminish production (apparently, as a reaction to the overproduction crisis), causing unemployment. Hence, the *Union* wished to alleviate the unemployment problem (or even to create the 'artificial labour shortage') by insisting on the 'two-for-one system'. It should be noted that some manufacturers, such as Mondron and Fourcault, supported the system, regarding it as a possible way to appease the *Union*. This was a minority view, however.[532] Yet the conflict around the job-sharing arrangement seems to be resolved soon after. On 15 May 1884, it was decided to allow 'two-for-one' employment, although the decision was primarily motivated by the 'heats' (hot weather), and was suggested for use 'with moderation'.[533] The compensations (*indemnités*) to be paid to factories that had been shut down due to strikes were mentioned on 7 April, yet no details of such arrangements were provided.[534] After this, the conflict with labourers, including the 'two-for-one' system, disappeared from the proceedings for some time.

It appears, therefore, that the 'two-for-one' conflict was the result of a short-term fluctuation caused by the 'American crisis', rather than a structural issue. However, the general trend indicative of the changing role of labour persisted. In particular, the reduction of wages started to feature prominently as the *Association's* objective from the 'American crisis' of 1884, as manufacturers regarded the lowering of the production price as the most important means of fighting the crisis, alongside the reduction of customs and transport tariffs.[535]

The *Association* even presented the reduction of glassblowers' wages as a 'humanitarian goal'. While no numbers were provided, the *Association* mentioned that glassblowers received the highest wages of all industrial workers, as no other craftsmen (the term *artisan* was used) could even hope to earn as much as a glassblower, no matter their ability and intelligence. Many other secondary workers at the glass factories, such as *étendeurs* (operators of annealers), glass cutters, packers and others, barely earned enough to make a living. Yet these auxiliary workers were more numerous; for every six glassblowers employed at a furnace, thirty others were active at the factory. So, according to the *Association's* logic, if there were production cost cuts to be made in the industry, the glassblowers' wages were the most logical starting point.[536] It is remarkable that the *Association* preferred not to cut the wages of other categories of workers (*étendeurs*, glass cutter, etc.), even though they were more numerous and had less of an impact on product quality. It is impossible to know whether the 'humanitarian rhetoric' was genuine.

In November 1885, it was remarked that, while the price of coal diminished, the share of labour in the total cost price amounted to 45% to 50%. Moreover, it was mentioned that the (non-specified) foreign competitors had an advantage in this respect, as they had to pay their

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[531] Private archive Gobbe, Association, Brouillons II, Séance 12 mars 1884, Séance 17 mars 1884, Séance 21 mars 1884

[532] Private archive Gobbe, Association, Brouillons II, Séance 24 mars 1884

[533] Private archive Gobbe, Association, Brouillons II, Séance 15 mai 1884

[534] Private archive Gobbe, Association, Brouillons II, Séance 7 avril 1884

[535] Private archive Gobbe, Association, Brouillons II, Assemblée Générale 27 juillet 1885 – Rapport sur la situation en 1884

[536] Private archive Gobbe, Association, Originaux C, Exposé de la situation par l'Ass-on des Maîtres de Verreries

workforce less. This is quite a remarkable statement, as it is generally assumed that the low labour cost was one of the main comparative advantages of the Belgian industry in general as well the glass industry in particular (see the chapter on comparative advantage in the introductory part). The organisation of *chômage* was presented as the surest way to lower wages.[537] While the exact reasoning behind this assumption was not provided, it may have been as follows: by executing the *chômage* (thus, shutting down a number of furnaces), unemployment among labourers would increase. As the number of job opportunities decreased, labourers would become willing to work for lower wages. On 3 December, 'progress' in this respect was discussed. According to the reports presented to the *Association*, multiple manufacturers 'succeeded' in reducing their labourers' wages by 10 to 20%. The *Association*'s president encouraged all other manufacturers to follow this 'good example'.[538]

It is logical to assume that the reduction of wages could only be achieved when labour was superfluous. This must have been the case due to the semi-permanent state of overproduction resulting from foreign competition, as discussed in the Partr 1.

The issue of 'two-for-one' re-emerged in 1901, as it was one of the demands of the *Nouvelle Union Verrière* (labour union) during a major strike. The union demanded that the arrangement be applied during periods of partial inactivity of factories.[539]

Later, as already mentioned in the Part 1, a sort of agreement known as *l'entente cordiale* between the *Association des Maîtres* and the *Nouvelle Union Verrière* was concluded in 1909, leading to an appeasement of the relationship between 'capital and labour' until the First World War. Moreover, tensions were alleviated to a degree by the mass emigration of glass workers in 1906 and 1907 in particular, which suggests that 'superfluous' workers could try their luck elsewhere in foreign countries.[540]

This is a clear indication that by the early 20th century, there was no longer a shortage of skilled labour. Quite the contrary, in fact. Due to the semi-permanent overproduction crisis, labour had become superfluous. This conclusion is corroborated by a remark made by Émile Vandervelde, a prominent Belgian socialist politician at the time, in his monograph on the labour movements in Belgium, published in 1891. Vandervelde wrote that for a long time demand for the labour of glassblowers had exceeded supply, yet 'for a few years' (i.e. in the late 1880s), the situation changed due to two factors. First, growing international competition led to overproduction, causing a fall in the demand for labour. Second, the introduction of tank furnaces made apprenticeships easier, thus increasing the supply of labour.[541] The second factor concerns the possible de-skilling, which will be discussed in more detail in Part 3. Yet, total employment in the window-glass industry grew considerably

[537] Private archive Gobbe, Association, Brouillons II, Séance 20 novembre 1885

[538] Private archive Gobbe, Association, Brouillons II, Séance 3 décembre 1885

[539] Misonne, "La crise verrière dans le bassin de Charleroi," 33-34; De Nimal, "L'industrie du verre à vitres en Belgique," 152-153; Poty and Delaet, *Charleroi pays verrier*, 99-103; Private archive Gobbe, Association des maîtres de verreries, Originaux D, Rapport sur la situation de la verrerie à vitres pendant les années 1900-1901-1902

[540] Poty and Delaet, *Charleroi pays verrier*, 108-111.

[541] Émile Vandervelde, *Enquête sur les associations professionnelles d'artisans et ouvriers en Belgique,* Tome I (Brussels: Imprimerie des travaux publics, 189&), 113.

during the same period: from 4,541 in 1886 to 9,763 in 1896 and 14,500 in 1906. The paradox of the growing abundance of labour despite increasing employment can at least partly be explained by the very chaotic character (i.e. prone to conjunctural crises) of industry during this period. For instance, the situation of overproduction occurred especially frequently between 1900 and 1914, causing the partial inactivity of factories.[542]

Thus, it appears that in the situation of a semi-permanent overproduction and overcapacity crisis from the 1880s onwards (and even more so after 1900), even the specialised labour of glassblowers became superfluous rather than scarce. The possible de-skilling of the labour force due to the introduction of the tank furnace could have contributed to the situation. In this context, the 'two for one' arrangement, championed by the *Union*, can be interpreted as an attempt to alleviate unemployment by creating an 'artificial labour shortage'. Within the industrial-district approach, this situation signals an important transformation, as the key resource (labour) shifted from 'scarce' to 'abundant' (or from a 'narrow resource' to an 'extensive resource'). Still, being abundant (or even superfluous) within the district, the specialised labour pool largely remained within the district, hence assuring its semi-monopolistic position. This situation was reinforced by the *Nouvelle Union Verrière*, which actively opposed the installation of new window-glass factories outside the Charleroi region.[543] On the other hand, the union actively encouraged emigration to the United States during the overproduction and unemployment crises.[544]

Nonetheless, the first instances of delocalisation of the window-glass industry within Belgium (to Antwerp and Tilly) had occurred by the early 20th century, possibly aided by the new situation. As specialised labour became abundant within the Charleroi region, glassblowers could, presumably, be 'lured away' more easily, despite the opposition of the *Nouvelle Union Verrière*. This is just an educated guess, however, as we do not possess sources on the recruitment of workforces for these new factories outside the traditional region.

As for the question of agency, it is worth noting that the relationships between employers (factory owners) and workers (glassblowers mostly) became increasingly defined by the *Association* by the late 19th century, meaning that employment and labour conditions were made more or less equal in all factories belonging to the *Association*. New members (factory owners joining the *Association*) had to 'abandon their liberty of action' regarding employment conditions upon entering into the *Association*, as was the case for E. Baudoux and N. Grégoroius who joined in 1895. It was stated quite explicitly on this occasion that the *Association's* members could not independently engage in negotiations on employment and labour conditions with the unions, as the *Association* regarded this as its prerogative.[545] In this way, the role of the collective agency (that of the *Association*) increased at the individual agency level (of individual manufacturers) where labour-related questions were concerned. The functions effectuated by the *Association* are in line with what De Leener regarded as functions of an employment syndicate, as we encounter all elements mentioned by him

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[542] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 98.
[543] Massart, *Verreries et verriers du Centre*, 25.
[544] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 105; Vandervelde, *Enquête sur les associations professionnelles,* Tome II, 124-125.
[545] Private archive Gobbe, Association, Originaux C, Assemblée Générale 29 mars 1895

(fixation and imposition of uniform employment and labour conditions, fixing of wages, resistance to workers' demands).

The *Association* as a sales syndicate: coordination of sales conditions

As previously noted, De Leener regarded the coordination of tariffs and prices as part of what he called the sales syndicates (*syndicats de vente*) alongside measures such as the limitation of production and distribution of sales. Therefore, this topic should be addressed here as well.

Indeed, the fixing of prices and tariffs for foreign markets was one of the main functions of the *Association* from the very beginning. The first table with standard tariffs appeared already at the first meeting in 1848. The regulation of prices cannot be separated from the standardisation of production. As will be discussed in more detail later (Part 3, Chapter 3.4 on properties and qualities of glass, whereby an example of a tariff table from 1848 will be provided[546]), various properties of glass, such as thickness and quality, became standardised in the second half of the 19th century, presumably as a deliberate policy of the *Association*, even if this process was not always smooth due to the attitudes of some members. The prices were reviewed regularly by the *Association* (at least a couple of times each year) during the whole period of its existence.

The fixing of prices was regarded as a *convention*, referred to by the *Association* in the proceedings by the date of approval, such as the *convention* of 3 December 1866 and so on. Given the principally liberal and non-interventionist stance of the *Association*, it is difficult to judge the extent to which these *conventions* were regarded as binding. Some insight into the common practice in this respect is offered by discussions held in 1870. While discussing the general situation of the glass industry at that time, Mr Francart commented on the 'lack of intelligence' (*inintelligence*) that accompanied the trade practices of most members. In particular, he complained about the fact that many of them violated the price *convention* of 3 December 1866. If we are to believe Francart, some were still using the prices of the *convention* of 22 April 1856.

The majority of members regarded this as a serious and even urgent problem. A special commission, consisting of Hindel and Francart, was formed to study this question. After long debates during multiple gatherings, it was decided to use the *convention* of 3 December 1866 as the price basis for all members. However, it proved to be difficult to persuade the three largest firms, *Bennert & Bivort*, J. Frison and *Société des Manufactures* (*Verreries de Mariemont*) to follow the *convention*.

The question of penalties for infractions of the *convention* was especially difficult. Francart, for example, while being the initiator of the whole discussion, opposed any kind of penalty, as he regarded the *Association* as a purely consultative organisation. However, he left open the possibility of a 'fine of some kind' (*amende quelconque*) for the offenders. It is not clear why he did not regard this as a penalty. Casimir Lambert, who also judged the *Association* to be a consultative organisation, regarded the *convention* primarily as a means towards the

[546] Private archive Gobbe, Association, Originaux A, Séance 28 novembre 1848

simplification of transactions between manufacturers and buyers as well as between manufacturers themselves. According to him, the common tariff base would help to avoid confusion. Dominique Jonet, however, was of the opinion that a kind of 'system of guarantees' in the event of violation of the *convention* would be desirable. This 'system of guarantees' required every member to contribute 500 Belgian francs per pot to a fund that would be managed by a special commission, which 'would act against violators'. The specific method of operation of this commission and the way it would apply the fund is unclear.

Eventually, the proposition for the confirmation of the *convention* of 3 December 1866, including the 'system of guarantees', was approved, but it remains unclear whether it had truly been made mandatory. The generally liberal stance of the *Association*, reluctant to impose any mandatory obligations on its members, comes to the fore again. It should be noted, moreover, that the adaptation of the *convention* of 3 December 1866 did not imply that all manufacturers would sell their glass at the same price, as everyone remained free to apply any 'reduction' (*rabais*), hereby adjusting the price at his own will. Rather, the *convention* implied a common base for the calculation of actual prices, depending on *rabais* as applied by every manufacturer individually.[547]

The *convention* of 3 December 1866 was put on the Association's agenda again in 1871, resulting in a revision increasing tariffs by 20%.[548] This time, the issue did not give rise to many debates, but the observation of prices, as laid down by the *Association*, soon proved to be deficient, despite being made mandatory by the *Association*'s statutes. This, at least, was the opinion of Casimir Lambert who proposed setting fines for the violators in 1873. However, it was apparent that nobody else really cared. These prices refer to the tariffs as imposed by *convention* of 3 December 1866 and adjusted multiple times on later occasions.[549] Somewhat later the same year, it had even been proposed to abolish fixed standard tariffs altogether, as they proved to be largely impossible to maintain. Nevertheless, the majority of members decided to maintain the system.[550]

The determination of tariffs for the sale of glass on foreign markets remained one of the *Association*'s core activities during its entire period of existence, but it is difficult to judge whether these tariffs were of a mandatory, semi-mandatory or voluntary nature. While the aforementioned *convention* of 3 December 1866 seemed to have been mandatory (at least theoretically), from the late 1870s on, the tariffs started to look rather voluntary. For example, when the *Association* decided to slightly increase the tariffs in August 1878, it mentioned that these prices were given *sans engagement,* which can be interpreted as voluntary.[551] In most cases, *sans engagement* is not even mentioned, making it impossible to judge whether these prices were voluntarily or not. At any rate, no sanctions for not respecting the set prices are ever mentioned after 1870.

[547] Private archive Gobbe, Association, Originaux A, Séance 21 février 1870, Séance 28 février 1870, Séance 14 mars 1870
[548] Private archive Gobbe, Association, Originaux B, Séance 28 décembre 1871
[549] Private archive Gobbe, Association, Originaux C, Séance 6 novembre 1873
[550] Private archive Gobbe, Association, Originaux C, Séance 7 février 1873
[551] Private archive Gobbe, Association, Originaux C, Séance 12 août 1878

Moreover, the fixing of prices, whether *sans engagement* (voluntarily) or mandatory, was basically limited to only a few markets (the United States, United Kingdom and, on some occasions, the Netherlands), although from circa 1890s on, the number of markets for which prices were set increased collectively. For instance, in 1891, prices were set explicitly for the markets of the United States, Australia, South America and Japan, the Netherlands, (East) Indies and China, 'Orient' and Canada.[552]

In conclusion, the fixing of prices can be regarded a part of a deliberate strategy, together with the standardisation of production, conducted by the *Association*. The standardisation strategy can be seen as an integral part of the functioning of the industrial district as a business organisation structure that allowed individual firms to reduce transaction costs when dealing with clients all over the world, resulting in shared positive externality (see Part 3, Chapter 3.4 on the specialisation and organisation of production or further discussion).

Nevertheless, it appears that the maintenance of any standards was often problematic, even when they had been formally established as mandatory. Any information on penalties and the way they were applied is very scarce, if not almost non-existent. Yet it appears that these penalties were not very effective, to say the least.

The *Association* as sales syndicate: limitation of production and distribution of sales

These two functions (the limitation of production and distribution of sales), which cannot be regarded separately as they were often discussed simultaneously, formed the main field of action of the *Association*. Here, two main mechanisms can be distinguished. The *chômage* was the main mechanism for limiting production, as it implied partial inactivity of the production capacity. For instance, participating firms would shut down their furnaces (*chômer*) for a limited period of time. Needless to say, this mechanism was most effective when overproduction occurred. Mechanisms for the distribution of sales were known by different names, such as *mutualité, convention de vente, entente pour la vente*, etc. These mechanisms could take on various forms, such as the 'voluntary' distribution of markets among members and/or fixing of prices for certain markets. Possibilities for common sales were discussed as well. Unfortunately, it is not possible to range these mechanisms according to the degree to which they deviated from the liberal 'ideal' of free competition. On the one hand, various mechanisms considered various aspects (*chômage*: production, *convention de vente*: sales). On the other hand, the exact detail of these arrangements is often missing.

The *chômage* arrangements were most popular in 1858-1859, when the first of such arrangements was implemented, and the 1880s.[553] The possibility of *convention de chômage* appeared on a few occasions in the late 19th-early 20th centuries, yet, generally, this mechanism seems to have fallen out of fashion. When such an arrangement was proposed in 1893, it was remarked that the *Association's* regulations forbade any kind of mandatory

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[552] Private archive Gobbe, Association, Originaux C, Assemblée Générale, 30 décembre 1891

[553] Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 372-373; Private archive Gobbe, Association, Originaux A, Séance 15 janvier 1859; Séance 19 janvier 1859; Séance 24 janvier 1859; Private archive Gobbe, Association, Originaux C, Séance 12 avril 1873; Private archive Gobbe, Association, Brouillons II, Séance 20 novembre 1885, Séance 3 décembre 1885, Séance 12 février 1886, Séance 12 avril 1886, Séance 21 mai 1885

limitation of production. Therefore, any such arrangement could only be made outside of the formal structure of the *Association*. Nevertheless, a voluntary *chômage* with the *Association* was still possible.[554] For instance, a *convention de chômage* with a 'unanimity condition' was proposed again in 1894.[555]

New types of arrangements, concerning the distribution of sales between manufacturers, was first proposed in 1875. Here, it was presented as an alternative for *chômage*. Instead of *chômage*, an arrangement concerning the regulation of trade on the international market, called *mutualité*, was presented by the *Association's* president. The *mutualité* would allow everyone to find outlets for their production in proportion to general demand. To this end, three groups of manufacturers would be formed. The general assembly of the *Association* would set fixed mandatory prices for each group. In order to prevent offences, penalties would be set. Moreover, the markets would be divided into three groups as well, namely England, United States and the rest. Each manufacturer would be free to choose a group to belong to.[556]

Many more arrangements for the organisation of sales on foreign markets followed from the 1880s on. To begin with, in 1882 a project of a *syndicat* for the trade with the United States, elaborated by a certain Mr Vanderlaet & C° (possibly a merchant, as this name does not appear in the lists of *Association*'s members) was discussed. Eventually, this proposition was rejected due to the already-existing 'direct relations' with this country. However, it was unanimously decided to elaborate a similar arrangement for China and Japan as, apparently, no 'direct relations' with these countries existed yet.[557] Yet, no further notices on this initiative were recorded in the *Association's* proceedings, suggesting that it died a silent death. In 1886, multiple manufacturers demanded the formation of two sales syndicates (*syndicat pour le vente*), one for the Netherlands and one for Belgium.[558] In the next year, the formation of a (trade) syndicate with a depot in Sydney was proposed, in recognition of the importance of the Australian market.[559]

Subsequently, proposals for tighter, more cartel-like arrangements were mentioned as well. In this context, the designations of *syndicat* and *entente*, rather than *convention* were used. For instance, in November 1887, the *Association* received two letters proposing the organisation of *syndicats*, one sent by Mr Merckens for a *Syndicat pour la Chine et le Japon*, another by Mr *Weyland* for a *Syndicat pour l'Angleterre*. The exact content of these proposition was not recorded, however.[560] In January 1888, it was mentioned that the *entente* for the Belgian market did not succeed, therefore this market remained open for 'free competition' (*libre concurrence*, as it was described in the proceedings), although the 'free competition' was somewhat questionable as prices were set by the *Association* (see paragraph on the fixing of prices above).[561] Therefore, it can be concluded that the *entente* implied a tighter, possibly cartel-like arrangement, limiting competition. In June 1888, Lebeau

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[554] Private archive Gobbe, Association, Originaux C, Assemblée Générale 18 août 1893
[555] Private archive Gobbe, Association, Originaux C, Assemblée Générale 14 septembre 1894
[556] Private archive Gobbe, Association, Originaux C, Séance 5 juillet 1875, Séance 6 novembre 1875
[557] Private archive Gobbe, Association, Originaux C, Séance 13 février 1882
[558] Private archive Gobbe, Association, Brouillons II, Séance 23 septembre 1886
[559] Private archive Gobbe, Association, Brouillons II, Séance 19 janvier 1887
[560] Private archive Gobbe, Association, Brouillons II, Séance 7 novembre 1887
[561] Private archive Gobbe, Association, Brouillons II, Séance 24 janvier 1888

proposed the formation of a committee that would set prices and control production for each market. While the President recognised that these ideas were 'very fine' (*ces idées sont très belles*), he considered their practical execution impossible.[562] In August 1888 a 'project' for a *syndicat pour la vente* in Belgium and the Netherlands was presented by Haidin, who would act as an 'agent' of such an arrangement. Although several manufacturers expressed an interest in the proposition, no further record of this project was made.[563]

Unfortunately, the *Association*'s proceedings do not mention explicitly whether such proposals were effectively implemented or not. Nevertheless, it seems that in most cases difficulties were encountered. Yet, despite the problems encountered during the negotiations on various arrangements (*conventions*) aiming at closer cooperation between manufacturers, an even more ambitious project was elaborated simultaneously by the *Association* (or, more exactly, by a special committee within the *Association*) in 1903. The proposed arrangement, known as the *Trust des Verreries Belges*, would unite all or 'almost all' Belgian window-glass factories within one singe enterprise, and would issue its shares. Yet, this project did not bear any fruit, which is not surprising given how difficult it had been to achieve even the much less far-reaching cooperation, as described previously (the *Convention pour la réduction des salaires et l'organisation d'un chômage,* for instance.[564] Interestingly, the engineer Oppermann, who was sent by the *Association* to the United States to study the latest technology such as glass-blowing machines (See Part 3, Chapter 3.2), reported on the organisation of American trusts upon his return to Belgium. It seems that the *Association* was actively gathering information not only on the latest technological developments, but on the business organisation as well. Upon his return, Oppermann advised the *Association* to 'group itself strongly' by forming a trust. In it, each firm would be represented by shares equivalent to their 'real value'. However, multiple members thought that an amalgamation of multiple firms into one trust would cause many difficulties regarding the administration of firms that were organised as limited liability companies.[565] Hence, despite a certain interest among at least some manufacturers, the project to merge all firms into one trust seems to have been considered unrealistic, and was therefore abandoned. More details on this failed project is provided by De Leener, who mentioned a trust called *Verreries Réunies de Belgique* in 1903, which most probably referred to the aforementioned project. According to him, this project failed for two reasons. On the one hand, the owners of the potentially participating firms feared that the value of their factories (which would become part of the new trust) might be underestimated. On the other hand, owners of multiple factories that still operated as family enterprises feared the loss of social prestige associated with the ownership of an industrial enterprise if it was to be incorporated into a larger trust.[566]

According to De Leener, a similar arrangement, called *Comptoir de Vente des Verres à Vitres Belges* was proposed in 1905. In this case, again, the formation of a limited liability company

[562] Private archive Gobbe, Association, Brouillons II, Séance 30 juin 1888
[563] Private archive Gobbe, Association, Brouillons II, Séance 31 août 1888
[564] Private archive Gobbe, Association, Originaux D, Assemblée plenière 25 octobre 1903, Assemblée plenière 21 décembre 1903, Brouillons IV, Rapport du Comité Spécial (inscribed between Assemblée Générale 23 octobre 1903 and Assemblée Générale 14 décembre 1903)
[565] Private archive Gobbe, Association, Originaux D, Assemblée Générale 7 septembre 1903
[566] De Leener, *L'organisation syndicale des chefs d'industrie*, vol. 1, 227-241.

to unite all Belgian window-glass manufacturers was proposed. Within the proposed structure, sales would have to be conducted in a centralised way. Nevertheless, participating firms would have preserved some of their autonomy. For instance, the origin (specific factory) would have been mentioned. The project did not produce any result, nor was it mentioned in the *Association's* proceedings.[567]

It is apparent that during the period from the late 1880s on, most attention was dedicated to the coordination of international trade by means of various *conventions*, while *chômages* fell out of fashion. Without a doubt, this development was due to the strengthening of international competition. Unlike *chômages* of the earlier periods, which were intended for the short term (several months), *conventions* were intended for longer periods, up to several years. These developments were certainly reminiscent of cartels. Unfortunately, it is often unclear to what degree these *conventions* were effectively implemented, making it difficult to judge whether it is appropriate to speak of a true cartel. Moreover, the individual manufacturers kept their freedom of trade to a large degree. At any rate, a move towards cartelisation can certainly be affirmed.

Internal cohesion of the Association

In order to judge the strength of an organisation as an actor, it is important to assess its internal cohesion (internal unity). In other words, the extent to which the participating firms always followed the *Association's* policy needs to be ascertained in order to understand better the relationship between the collective (the *Association*) and individual (participating firms) agency. The *Association*'s proceedings provide only limited information in this respect. Yet, on some occasions, 'dissidents' (the term was used as such in the proceedings) who opposed several of the *Association*'s decisions and policies were mentioned explicitly. This allows us to research what set these 'dissidents' apart from the rest.

Moreover, on some occasions, the question of internal cohesion of the *Association* appeared to have been intrinsically connected to the question of the physical (geographical) limits of the industrial district and factors that defined these limits such as the labour pool. This was particularly the case for the *Convention pour la Réduction des Salaires et l'Organisation d'un Chômage* (hereafter: *Convention* of 1902-1904).

Hence, the purpose of this chapter is to research the limits of the collective agency of the *Association* and the factors that defined these limits. To what degree could the *Association* conduct common policy, and what factors strengthened and weakened this policy? What exactly set the 'dissident firms' apart?

Internal cohesion and the coordination of production

As noted, the coordination of sales conditions as well as the limitation of production and distribution of sales were among the core functions of the *Association* (the *Association* as sales syndicate).

[567] Ibidem

The first explicit mention of 'dissidents', deliberately violating the *Association's* policies, was recorded in 1870 in the context of the fixing of prices (more on this in the paragraph on the *Association* as sales syndicate). On that occasion, three firms, *Bennert & Bivort*, *J. Frison* and *Société des Manufactures* (*Verreries de Mariemont*) were reluctant to follow prices set by the *Association*, designated as the *convention* of 3 December 1866.[568] . Moreover, it is striking that on at least one occasion (convention of 3 December 1866) these where exactly the three largest firms (*Bennert & Bivort*, *J. Frison* and *Société des Manufactures* (*Verreries de Mariemont*) that opposed the common policy on the fixing of tariffs. In my opinion, this was hardly a coincidence as, as the theory goes, large enterprises are less likely to cooperate in the context of industrial districts. Unfortunately, no names of offenders or 'dissidents' were mentioned on other occasions, even though we know that the enforcement of *conventions* on prices and tariffs remained problematic.

More cases of 'dissident behaviour' were recorded in the context of the limitation of production (*chômage*) and distribution of sales (see paragraph on the *Association* as sales syndicate). The problems already began with the first *chômage* arrangement, concluded in 1858-1859. By January 1859, eight months after the initiation of the *chômage* arrangement, the *Association* started a procedure against *Bennert & Bivort*, due to their 'unloyal behaviour'. Contrary to the agreement, *Bennert & Bivort* did not put their furnaces on inactive, thus gaining an unfair advantage over the members who did obey the rules of *chômage*. The matter initiated a whole series of discussions, resulting in a severe crisis within the *Association*, making it inactive for almost a year, as no gatherings were held between 25 February and 10 December 1859. After the resumption of activities, the *Association* rendered its objectives more modest for quite some time, putting fewer demands on its members.[569] The formation of a *convention de chômage* was again proposed in May 1865, but this proposal was rejected. In this case, again, *Bennert & Bivort* where its most proponent opponents.[570]

No motivation for the dissident behaviour of *Bennert & Bivort* in the 1850s and 1860s was recorded in the *Association's* proceedings. In the following decades, ideological arguments were made on several occasions. For instance, ideological fault lines between interventionist and non-interventionist (liberal) visions within the *Association* became apparent in the course of discussions on a proposed *chômage* arrangement in 1873. At the session of 8 March 1873, Andris, being a proponent of the former, declared that the situation (overproduction crisis) could be improved by *chômage*, whereby every member would participate 'without compensation' (*sans indemnité*). Representing the non-interventionist position, Morel declared that 'free competition is conducive for the development of industry, while conventions result in illusions and bring about "false prosperity"'[571] Andris responded that it was better to unite in times of crisis rather than ruin themselves for the sake of the free-competition principle, receiving applause for this intervention. The subsequent voting

[568] Private archive Gobbe, Association, Originaux A, Séance 21 février 1870, Séance 28 février 1870, Séance 14 mars 1870

[569] Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*, 372-373; Private archive Gobbe, Association, Originaux A, Séance 15 janvier 1859; Séance 19 janvier 1859; Séance 24 janvier 1859

[570] Private archive Gobbe, Association, Originaux A, Séance 30 mai 1865

[571] Private archive Gobbe, Association, Originaux C, Séance 8 mars 1873, Quote: "les conventions entretiennent les illusions & ne peuvent amener qu'une prospérité factice"

clearly indicated that the majority of the *Association's* members adhered to Andris's views, as there were 19 votes for the new *chômage* arrangement and nine against.[572] More discussions followed, whereby four members (Hansotte & Cie, Crets Gérard, L. Lambert & Cie and Gobbe) refused to join the *chômage*. Despite these dissidents, the principle of *chômage* was approved by voting.[573] The *chômage* was finally approved on 12 April with 25 votes for, three against and two abstentions. During the accompanying discussion, Casimir Lambert declared one more time that he remained a staunch opponent of any *convention de chômage* in the future.[574] After more discussions, the *convention de chômage* was reaffirmed on 16 September 1873.[575]

This example is quite revealing, as it sheds light on the uneasy coordination within the *Association*, whereby non-interventionist (liberal) and interventionist views became explicitly opposed, as exemplified by the discussion of Andris and Morel. Even when the problems (the overproduction crisis in this case) were generally acknowledged, many members remained sceptical about closer cooperation, which resulted in long debates. Nevertheless, the majority were in favour of measures (*chômage*). However, the discussions mainly considered the distribution of measures, as the original proposition was rather disadvantageous to small firms. Unfortunately, due to a lack of data for this period, we do not have enough details on the 'dissident firms' (Hansotte & Cie, Crets Gérard, L. Lambert & Cie and Gobbe), such as their size.

In the following decades, *chômage* arrangements were proposed and discussed on multiple occasions, yet no explicit cases of dissident behaviour were recorded, with the exception of Casimir Lambert who remained a firm opponent of such arrangements on ideological grounds, for instance in 1882 and 1883.[576]

<u>Conventions of 1902-1904 and 1910 and the definition of industrial district</u>

The question of internal cohesion prominently came to the fore in 1902-1904, when a new *Convention pour la réduction des salaires et l'organisation d'un chômage* was discussed (see paragraph on the *Association* as employment syndicate). This arrangement engendered lengthy discussions, which are quite revealing as they expose some challenges faced by the *Association* as a governing body of the industrial district. On the one hand, it shows that the pursuit of a closer collaboration and tighter organisation became ever more prominent. On the other, multiple difficulties emerged. Most pronounced was the fact that the member firms located outside the region were much less inclined towards forming a close business association. The 'specific circumstances' of these 'outsiders' were often alluded to, although, unfortunately, the exact nature of these circumstances was never described. Yet the question clearly emerged whether firms within the district should form a close association, excluding those outside. Multiple discussions were dedicated to this question, and they provide us with some evidence of a collective identity of the industrial district. It was through these

[572] Private archive Gobbe, Association, Originaux C, Séance 8 mars 1873
[573] Private archive Gobbe, Association, Originaux C, Séance 18 mars 1873
[574] Private archive Gobbe, Association, Originaux C, Séance 12 avril 1873
[575] Private archive Gobbe, Association, Originaux C, Séance 16 avril 1873
[576] Private archive Gobbe, Association, Originaux C, Séance 24 mars 1882; Private archive Gobbe, Association, Originaux C, Séance 11 mai 1883

discussions that it became clear (to us now as well as to the glass manufacturers themselves at the time) that the firms within the district shared a common destiny in many respects, while those outside (even if relatively close by) often had different interests. At the same time, individualistic attitudes of some firms even within the district of Charleroi remained a fundamental obstacle to closer coordination, as will be shown in the following.

During the discussion of 12 September 1902, most members agreed that the *convention* should unite all firms of the industrial regions of Charleroi (*bassin de Charleroi*) with the exception of *Verreries de Jemappes*, *Verreries de Binche* and *Verreries de Mariemont* which were actually located outside of the region. As noted previously (see Part 1, Chapter 1.5), the *Verreries de Binche* and *Verreries de Mariemont* were located in the region of Centre (the latter still quite close to Charleroi), while the *Verreries de Jemappes* was located even further away in the region of Borinage. However, one member, Lambert, would only consider a possible exception for *Jemappes* and not for *Binche* and *Mariemont*.[577] The question of whether these firms should be required to join the *Convention* would appear time and again in the course of subsequent discussions.

On 15 September 1902, it was mentioned that the firms of *Jemappes*, *Binche* and *Mariemont* were 'in special circumstances' compared to those of the region of Charleroi.[578] Unfortunately, the nature of these 'special circumstances' was never described explicitly. Yet, on multiple occasions, it was noted that these firms had distinct relationships vis-à-vis labourers and the labour movement. For instance, speaking of *Mariemont* specifically, it was stated that wages were lower there than in Charleroi because this firm could put up stronger opposition to labour unions. Moreover, the labour unions themselves emerged later in the Centre than in Charleroi. During the same meeting, one member, Noblet, noted that the 'difficulties in Charleroi and Centre were of a distinct nature', albeit without providing further details. Another member, H. Lambert, even stated that the firms of *Jemappes*, *Binche* and *Mariemont* should be considered 'as if they were situated in another country', stating that their fortune did not have any influence on that of the firms of Charleroi, either in a positive or negative sense.[579]

Nevertheless, the question remained as to whether these firms should be made part of a proposed *convention*. Apparently, many of the *Association's* members still wished to involve these firms in the new arrangement. Yet, these firms themselves were not at all eager to participate as, apparently, the *Verreries de Jemappes* had already rejected the first proposal for the *Convention* in September 1902. Reacting to this, the majority of the *Association*'s members decided that it would be better to conclude the *convention* between the firms of Charleroi exclusively, without worrying about the attitude of the dissident firms of the Centre (*Mariemont* and *Binche*) and *Jemappes*.[580]

And yet, some members still believed that the participation of *Jemappes*, *Binche* and *Mariemont* was necessary for the success of the *Convention*. For instance, Louis Lambert stated that he would only accept the project of a convention if *Jemappes*, *Binche* and

[577] Private archive Gobbe, Association, Brouillons IV, Assemblée 12 septembre 1902
[578] Private archive Gobbe, Association, Brouillons IV, Assemblée Générale 15 septembre 1902
[579] Private archive Gobbe, Association, Brouillons IV, Assemblée 22 septembre 1902
[580] Private archive Gobbe, Association, Brouillons IV, Assemblée 10 octobre 1902

Mariemont as well as *Courcelles* (a 'dissident' firm within the region of Charleroi) participated. Responding to this, H. Lambert stated that only identical interests should be united and, in his opinion, the interests of the firms of Centre and Jemappes were very distinct from those of Charleroi; he maintained that the bringing together of distinct interests within one arrangement would weaken it. Louis Lambert responded that all firms still had similar interests and labour conditions. Moreover, the firms from outside Charleroi could still 'lure away' some categories of labourers from Charleroi by offering them higher wages.[581]

Hence, while the discussion continued on whether the firms of *Jemappes*, *Binche* and *Mariemont* should truly belong to the *convention*, the 'unanimity condition' within the region of Charleroi (*condition d'unanimité dans le Bassin de Charleroi*) was generally accepted.[582] And yet it was precisely this 'unanimity condition' that made it difficult to actually implement the *Convention*, because a refusal or 'conditional refusal' of only one firm would make the entire arrangement impossible. For instance, in January 1903, two 'dissident' firms, *Verreries de Courcelles* and *Verreries de Hamendes* only wished to participate on condition that all other firms would confirm their participation first, causing a virtual stalemate, as none would make the first move in declaring their participation.[583]

Hence, despite the generally felt need (or even urgency) for closer collaboration between firms, no arrangement could be put in place for some time. By late May 1903, the situation was described as 'disastrous'.[584] Worse still, in June the *Association* stated that 'unanimity is required, yet impossible'.[585] And in July 1903, the *Association* stated that while the unanimous opinion of all members confirmed that the lowering of prices though the reduction of wages was absolutely necessary by means of a unanimous convention uniting all firms, this unanimity could not be achieved due to the 'special conditions' of some (unspecified) firms.[586]

The negotiations for a *C*onvention were resumed in early 1904. Once more, the *Verreries de Jemappes* and *Verreries de Binche* proved to be the main dissidents. Responding to the accusations, the representative of *Jemappes* stated that his firm found itself in the same circumstances as *Binche* considering the labour force, circumstances that were quite distinct from those of Charleroi. After this, the majority seems to have adopted the view that the *C*onvention should apply within the region of Charleroi only. Still, the question remained as to whether *Verreries de Mariemont* should be considered as belonging to the *convention*. According to L. Lambert, while *Jemappes* and *Binche* did not belong to the *Convention*, *Mariemont* should, as it shared many of the same conditions as the factories from the Charleroi region. Moreover, he remarked, *Jemappes* and *Binche* were already applying measures that the *Convention* intended to establish within the region of Charleroi. After this, in January 1904, the *Convention*, comprising a reduction in wages as well as the regulation of

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[581] Private archive Gobbe, Association, Brouillons IV, Assemblée 20 octobre 1902
[582] Private archive Gobbe, Association, Brouillons IV, Assemblée 22 décembre 1902, Assemblée 31 décembre 1902, Assemblée 19 janvier 1903
[583] Private archive Gobbe, Association, Brouillons IV, Assemblée 25 janvier 1903
[584] Private archive Gobbe, Association, Brouillons IV, Assemblée Générale 22 mai 1903
[585] Private archive Gobbe, Association, Brouillons IV, Assemblée du Comité 12 juin 1903, quote : "Il faut unanimité et cette unanimité n'est pas possible"
[586] Private archive Gobbe, Association, Brouillons IV, Assemblée Générale 8 juin 1903

apprenticeships, was finally adopted after more than a year. *Jemappes* and *Binche* were excluded.[587]

However, despite the conclusion of this convention, complete unanimity within the region of Charleroi was still not achieved, as negotiations with a couple of dissident firms (*Verreries de la Roue*, *Verreries de l'Étoile* and *Verreries Belges*) were mentioned. It is not clear how their opposition influenced the functioning of the *convention*.[588] At any rate, this instance illustrates how difficult it was to reach unanimity, despite the generally felt necessity.

This long story makes clear how important labour was for the industrial district. It can even be stated that the definition and limits of the district itself were defined by labour, understood as a localised pool of highly specialised and skilled workers. Despite the lack of details, the 'specific circumstances' of the factories of *Jemappes* and *Binche* were clearly related to the labour question. Their location (relatively) far away from the Charleroi region, meant that these firms could conduct their own human resources policy more or less independently of the firms from the Charleroi region. This is attested by the aforementioned remark by L. Lambert concerning their wage policy. The firms within the Charleroi region could not conduct a wage policy (in this context, wage reduction) on their own, as they shared a common labour pool, and labourers would simply move to another factory nearby that offered higher wages. Therefore, a common policy, as defined by the *Convention*, was necessary, yet difficult to achieve because of the 'unanimity condition'. However, without that 'unanimity condition', it would have been of little use precisely because of the aforementioned reasons ('floating' workforce within a single labour pool, which could easily move from one factory to another).

The last arrangement concluded before the First World War concerned the 'resistance to the demands of labour unions' (*Convention de résistance aux exigences syndicales ouvriers*), or the Convention of 1 September 1910. This time, it was decided from the first proposition on to limit this *Convention* to the manufacturers of the region of Charleroi, explicitly excluding those from the Centre and elsewhere. Within the region, the unanimity condition was required. The *Convention* had a very specific purpose of resisting the union's demands for a 5% increase in wages.[589]

Here, it was implicitly reaffirmed that the industrial district was defined by the labour pool first and foremost. It is therefore not surprising that the firms from outside the region (and hence of the common labour pool) were explicitly excluded. Interestingly, it was remarked that the *Verreries de Mariemont* should not hire workers from the region of Charleroi, although it is not clear by what means it would have been possible to prevent this. At any rate, this instance marks the ambiguous, in-between position of this firm. While located outside the region of Charleroi strictly speaking, it was still close enough to attract labourers from there.[590]

[587] Private archive Gobbe, Association, Brouillons IV, Assemblées 25 et 26 janvier 1904
[588] Private archive Gobbe, Association, Originaux D, Séance du 29 janvier 1904
[589] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 18 août 1910
[590] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 22 août 1910

In concluding this section, it can be argued that the common labour pool, acting as a 'key resource', was fundamental for the definition of the industrial district. Sharing this resource made firms dependent on each other, as the firms located within the district were limited in their possibilities to conduct an independent human resources policy. Therefore, coordination between firms situated within the district was necessary, albeit difficult to achieve. Because of this, paradoxically, being located within the district could give rise to disadvantages as well. The 'lack of unity' among firms in the Charleroi region was clearly perceived as a major hindrance. The majority of the *Association*'s members acknowledged the need for more unity, yet the move towards this goal proved to be a difficult one. In the course of more than a year, most discussions were dedicated to this objective, and all the limitations came to the fore. In a way, in these discussions the manufacturers reaffirmed for the first time the specific character of the industrial district of Charleroi, as a result of which the borders of the district had to be drawn almost literally. Firms situated outside the district, such as *Jemappes* and *Binche*, had a (potential) advantage that allowed them to conduct their own independent human resources policy – namely, their workers could not easily leave and go to another factory.

The firms of *Jemappes* and *Binche* clearly did not belong to the district of Charleroi, as defined by the common labour pool. Therefore, they were less inclined to cooperate and follow the common policy, as defined by the *Convention*. The *Verreries de Mariemont*, on the other hand, was a literal border case. The fact that it was allowed into the *Convention* despite being located outside the Charleroi region, can be attributed to the fact that it was still located much closer to Charleroi geographically than *Jemappes* and *Binche*. It might also havehave more or less shared in the same labour pool as the factories of Charleroi.

Not all dissident firms were located externally, however. The *Verreries de Courcelles*, *Verreries de Hamendes*, *Verreries de la Roue*, *Verreries de l'Étoile* and *Verreries Belges* were all located in the Charleroi region. Unfortunately, their motivation was not mentioned explicitly in the proceedings. The size of a firm can be seen as a plausible hypothesis, as it is reasonable to assume that larger firms were less dependent on cooperation due to their economic clout. Unfortunately, no exact data on this matter is available for this period. In his article (1904), De Nimal provided a list of all Belgian window-glass factories with the number of tank furnaces and pot furnaces[591] (see Table 18 below).

[591] De Nimal, "L'industrie du verre à vitres en Belgique," 150.

Table 18: Relative size of the Belgian window-glass factories in 1904

	No. of tank furnaces	No. of pot furnaces
Verreries Bennert et Bivort	3	-
Verreries de Jumet	3	-
Verreries des Hamendes	3	1
Verreries D. Jonet	3	-
Verreries de Jemappes (1 de relai*)	2	-
Verreries Belges	2	1
Verreries de la Roue	2	-
Verreries de Courcelles	2	-
Verreries de Mariemont	2	-
Verreries de l'Étoile	2	-
Verreries de l'Ancre (1 de relai*)	1	-
Verreries de Lodelinsart	1	-
Verreries de Binche	1	1
Verreries du Long-Bois	1	-
Verreries des Piges	1	-
Verreries de la Marine	1	-
Verreries Léon Mondron	1	1
Verreries Schmidt-Devillez	1	-
Verreries Desgain Frères	1	-
Verreries E. Fourcault	1	-
Verreries Gobbe-Hocquemiller	1	-
Verreries Goffe et Fils	1	-
Verreries H. Lambert	1	-
Verreries Georges et Frères	-	1

Source: De Nimal, "L'industrie du verre à vitres en Belgique," 150.

*presumably meaning that one furnace was inactive

Taking the number of tank furnaces as an indication of the enterprise size, roughly three groups can be distinguished: large enterprises (three furnaces, four enterprises), mid-size enterprises (two furnaces, six enterprises), and small enterprises (one furnace, thirteen enterprises). It appears that one dissident firm (*Verreries des Hamendes*) fell into the large-size category and four (*Verreries de Courcelles*, *Verreries de la Roue*, *Verreries de l'Étoile* and *Verreries Belges*) within the mid-size category. Hence, size alone cannot explain the dissident behaviour, although larger firms were more inclined towards it. Moreover, the simple number of furnaces is a rather rough indicator, as production might have varied due to other factors, such as periods of inactivity. This is exemplified by data published by Lalière (1912), who presented a table of all Belgian window-glass factories with their yearly production. At that moment, *Verreries des Hamendes* possessed two active and one inactive tank furnaces and had the largest annual production of all window-glass factories in Belgium, totalling 5,200,000 m^2. It was followed by the *Verreries Bennert et Bivort et Courcelles Réunies* (an amalgamation of two enterprises), with four active and one inactive tank furnaces and reaching annual production of 5,000,000 m^2. The *Verreries Belges* followed as the fourth-largest enterprise (preceded by the *Verreries D. Jonet*, with annual production of 4,500,000 m^2) with two active tank furnaces and an annual production of 3,840,000.[592] On the other hand, *Verreries de la Roue* and *Verreries de l'Étoile* were not listed by Lalière. Already in 1907, these firms were mentioned as being *en non activité* (*Verreries de l'Étoile*) and *en liquidation* (*Verreries de la Roue*), indicating that these enterprises went out of business around that time.[593]

Hence, out of the five dissident firms of 1902, the three 'surviving' were among the largest of the industry in 1912, while two perished.

<u>Regulation of relationships between the *Association's* members</u>

The degree of regulations imposed by an organisation upon its members is indicative of the internal cohesion as well. There are not many mentions of such regulations in the *Association*'s proceedings. While it is possible that not everything was recorded, the absence of any conflicts or complaints concerning relationships between member firms in the proceedings at least suggests that the *Association* did not regulate commercial relationships between its members in any way, which was in accordance with its principally liberal stance. The commercial relationships between members and non-members remained largely unregulated as well. For instance, in 1851, the *Association* formally allowed its members to buy glass from non-members without restrictions.[594]

One exception that appeared a few times in the 1860s, concerned the mutual trade in pots (crucibles) for glass melting. On 10 December 1859, it was agreed that members could sell pots to each other at 70 Belgian francs per pot. As for the sales of pots to non-members, the *Association* was yet to decide whether this should be allowed or not.[595] Apparently, the *Association* decided on the latter course of action, as in October 1864 the firm *Brasseur & Cie* had been accused of violating the regulations by selling pots to non-members. No sanctions were pronounced on this occasion, however.[596] Somewhat later the same month, sanctions for such violations were fixed at 100 Belgian francs for each pot sold to a non-member.[597] This prohibition was confirmed once more in 1866.[598]. No explicit motivation for this ban was mentioned. Possibly, it was intended to disadvantage non-participating enterprises in order to weaken their position against *Association* members, or to force non-members to join the *Association*.

The topic resurfaced in 1873, when it was unanimously decided that it would be prohibited to all members would be prohibited from selling any kind of materials or equipment to non-members, effectively prohibiting any commercial relations between members and non-members. This implied the strengthening of previous practices, as only the trade in pots had been prohibited previously.[599] In 1874, *J. J. Cornil & Cie*, a manufacturer of refractory

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[592] Lalière, "Les industries du verre," III. 6, p. 18
[593] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 234.
[594] Private archive Gobbe, Association, Originaux A, Séance 4 février 1851
[595] Private archive Gobbe, Association, Originaux A, Séance 10 décembre 1859
[596] Private archive Gobbe, Association, Originaux A, Séance 24 octobre 1864
[597] Private archive Gobbe, Association, Originaux A, Séance 31 octobre 1864
[598] Private archive Gobbe, Association, Originaux A, Séance 12 mars 1866
[599] Private archive Gobbe, Association, Originaux C, Séance 7 février 1873

materials as well as glass, demanded that the *Association* abolish the prohibition of trade in materials between members and non-members. Obviously, this prohibition went directly against his interests, as it prohibited him from delivering refractory products to non-members. Yet the assembly rejected his proposal.[600]

From the point of view of the business organisation within the industrial district, this instance shows that there must had been a widespread practice of manufacturers supplying each other, which is a clear example of an industrial-district externality. Apparently, the *Association* aimed at limiting the benefits of this externality to members only.

Conclusion

It can be noted that the most prominent dissident firm, *Bennert & Bivort*, was also the largest one. This is in line with expectations, provided larger firms could rely on their own internal agglomeration economies (scale effects due to the larger production unit), hence making them less dependent on the external economies of scale provided by the industrial district. One dissident entrepreneur, Casimir Lambert, opposed any kind of restrictive arrangement imposed by the *Association* upon its members, such as *chômage*, on ideological grounds. As a staunch liberal (see section on the political ideology of the *Association*), he generally opposed interventionist measures. Yet it is questionable whether the dissident behaviour of *Bennert & Bivort* and others was motivated by ideology, because from a pragmatic point of view it seems more plausible that they acted as such because it benefited them.

During the course of discussions on the *Convention* of 1902-1904, a special group of 'dissidents' emerged, consisting of *Verreries de Jemappes*, *Verreries de Binche* and *Verreries de Mariemont*. In this case, the location proved to be of primary importance, as these firms were located outside the Charleroi region. More specifically, the presence of the specialised labour pool of glassblowers within the region appears to have been the decisive factor. The firms that were located in the Charleroi region were bound to the shared labour pool, which 'forced' them to act together, while these located outside had more autonomy in the management of their workforce. Moreover, as shown by Widukind de Ridder, this situation was reinforced by the policy of the *Nouvelle Union Verrière*, which was only open to workers living in the Charleroi region. Those living outside were not allowed to join the union, and hence could not be employed in the Charleroi region, as the union still controlled recruitment to a large degree in the early 20th century.[601] In this way, the limits of the Charleroi labour pool were defined by the 'artificial' limits set by the labour union alongside 'natural' limits defined by physical distance.

International activities of the Association

As already discussed (Part 1, Chapter 1.1, the theory of industrial districts as business structure organisation), Harald Bathelet et al. (2004) regarded the exchange of information between the district and the outside world as essential to the functioning of the district. The establishment of these interactions, called 'pipelines', required deliberate efforts, as opposed

[600] Private archive Gobbe, Association, Originaux C, Séance 23 mai 1874
[601] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 99.

to the largely spontaneous circulation of information within the district, called 'buzz'. Interestingly, Bathelt et al. spoke of the role of individual firms for the establishment of 'pipelines' only.[602] This paragraph will explore how a BIA, such as the *Association*, was also able to take on this function (establishing of 'pipelines' for the exchange of information on the international level).

The *Association* was, indeed, actively involved in international activities, which included the gathering of information on the state of foreign markets, technological development within the industry, labour questions and other issues, as well as establishing contacts with foreign colleagues as well as international promotion.

Some of these activities are discussed elsewhere in this thesis. For instance, the cooperation between the *Association* and the Belgian government (the Ministry of Foreign Affairs primarily) in the context of contacts with consular networks, the exploration of foreign markets and international promotion, are discussed further in this chapter, while the *Association*'s international activities related to technology and innovation are dealt with in Part 3, Chapter 3.2.

Arguably, all international contacts are about the sharing and exchange of information in one way or another (i.e. establishing 'pipelines'). The following paragraphs will discuss the 'passive' sharing of international information among the *Association*'s members, as well as more active contacts with foreign colleagues.

While the gathering and exchange of information was the main focus of the *Association*'s international activities, on some occasions circumstances 'forced' it to engage in more active international strategies. For instance, the *Association* even tried to influence the American Congress to prevent protectionist legislation. Moreover, in the context of the general development of the Belgian window-glass industry and its position on the international market, this case provides an idea of an almost desperate fight by the *Association* to prevent the loss of the American market.

Sharing of information between the members

Before discussing the international contacts established and maintained by the *Association*, its role as a forum for the sharing of information on international affairs among the members themselves can be addressed. Indeed, on multiple occasions, especially from the 1870s on, various members presented their reports or short communications at the meetings of the *Association*. While the exact sources of this information are almost never quoted, it can be assumed that many members acquired information from their multiple foreign contacts. Many manufacturers had their own agents in various countries (see below). In terms of the theory of Bathelt, Malmberg and Maskell (see Part 1, Chapter 1.1), this was an example of local 'buzz'; yet, this 'buzz' was fed by global 'pipelines'.

For example, in 1875, Gorinflot presented a report on the state of the French window-glass industry, directing attention to the fact that the French formed a cartel-like agreement on

[602] Bathelt, Malmberg and Maskell, "Clusters and knowledge"

their internal market.[603] Speaking in 1878, de Dorlodot informed members about the state of the American glass industry in Pittsburgh. According to his sources (he mentioned a 'recent American survey of the glass industry' without further details) there were 54 factories that employed 4,570 workers in Pittsburgh at that time. The total production capacity amounted to 79 furnaces and 721 pots, although only 50 furnaces and 485 pots were active at that moment. Of these, only 15 produced window glass.[604]

In 1879, a letter from Andris Jochams, one of the *Association*'s members, was read out at a meeting. The letter informed members about the increase of prices by French glass manufacturers, and, even more interestingly, about the petition that had been addressed by the German manufacturers to their government, demanding protection from the imports of Belgian glass by means of the adjustment of import duties.[605] In 1882, an unnamed member informed the *Association* about the worsening of commerce with Spain due to the increased import duties in this country.[606]

The foreign press was discussed during the *Association*'s meetings as well. For instance, in 1883, various articles from American newspapers, related to the upcoming strikes and other issues related to the American glass industry, were discussed. The information received and discussed in this way helped the *Association* to decide on common policies, such as the fixing of prices, in the face of American competitors. This was of special importance as the Belgian window-glass industry was living through a severe crisis at that moment.[607]

The growing influence of the labour movement and subsequent conflicts engendered more interest in the labour relationships abroad. For instance, in 1884, an article from the English media on a new type of arrangement between a certain Mr Hartley (most probably, an English glass manufacturer) and his labourers was read out and discussed at the *Association*'s meeting. It was decided to write a letter (possibly to Mr Hartley himself) in order to acquire more information about the nature of this arrangement.[608]

On one occasion in 1886, Léopold de Dorlodot informed the *Association* about the prices and the market situation in general in London by telegram from that city.[609]

Hence, it may be concluded that individual members themselves formed an important source of information on foreign affairs to their peers within the *Association*.

[603] Private archive Gobbe, Association, Originaux C, Séance 28 août 1875
[604] Private archive Gobbe, Association, Originaux C, Séance 11 février 1878
[605] Private archive Gobbe, Association, Originaux C, Séance 24 février 1879
[606] Private archive Gobbe, Association, Originaux C, Séance 13 février 1882
[607] Private archive Gobbe, Association, Brouillons II, Séance 24 septembre 1883
[608] Private archive Gobbe, Association, Brouillons II, Séance 22 octobre 1884
[609] Private archive Gobbe, Association, Brouillons II, Séance 12 avril 1886

Contacts with foreign colleagues

Gwilliam and the British

As for the contacts with foreign colleagues, the *Association* seems to have had close ties with its English counterpart, described as the 'English Association of Glass Masters' (*Association of Maîtres-verriers Anglais*) in the proceedings. Its representative, mentioned as Gwilliam in the *Association's* proceedings, not only maintained correspondence with the *Association* over many decades, but had also visited Belgium and attended the *Association*'s meetings on several occasions. This Gwilliam must have been George Gwilliam, the permanent secretary of the British [window-glass] Manufacturers' Association.[610] Gwilliam first appeared in the *Association's* proceedings on 19 September 1865, when the president informed members about negotiations with Gwilliam on the topic of prices to be fixed for England.[611] It would be of no use to list all mentions of Gwilliam within the *Association*'s proceedings, as they occurred at least several times every year over two decades until the late 1880s, with the last mention of his name dating to 1887.[612]

In most cases, the topics discussed with Gwilliam concerned the adjustment of prices. He also informed the *Association* about the current state of the English glass market. In general, it can be stated that a sort of common interest was sought after by both Belgian as well as English glass manufacturers, the latter being represented by Gwilliam. This was stated quite literally in the proceedings upon his first mission to Belgium in 1866. Gwilliam informed the *Association* that the domestic English production was insufficient at that moment. Because of this, he (and, logically, the English manufacturers he represented) were not opposed to Belgian imports. Rather, he proposed the 'adjustment' (that is, increase) of the price of Belgian glass. Understandably, Belgian manufacturers were rather reluctant to follow this proposal, as this would have weakened their competitive position against English counterparts. The fact that Gwilliam complained about 'too low' prices of Belgian glass in comparison with English glass clearly indicates that low prices must have been the main comparative advantage of Belgian firms of that time.[613] Despite the disagreement, this proposal was repeated time and again on other occasions thereafter, and the contacts between the *Association* and Gwilliam continued for two decades, indicating that both parties considered cooperation necessary and useful. For example, a few years later, in 1868, Gwilliam visited Belgium personally to discuss the matter, as he considered 'the circumstances favourable for the increase of Belgian prices [for the English market].' As a result of the discussion, the *Association* agreed with Gwilliam to increase prices. Yet was emphasised that 'every member remained free' in their ultimate decision, suggesting that it was regarded as a recommendation rather than an obligation.[614]

In September 1873, a letter sent by Gwilliam caused a whole discussion on the matter of prices, as it appeared that Belgian glass was at least 35% cheaper than its English counterpart. It was remarked that English glass was of better quality than Belgian, but

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[610] Barker, *The Glassmakers. Pilkington,* 122.
[611] Private archive Gobbe, Association, Originaux A, Séance 19 septembre 1865
[612] Private archive Gobbe, Association, Brouillons II, Séance 1 octobre 1887
[613] Private archive Gobbe, Association, Originaux A, Séance 16 mars 1866
[614] Private archive Gobbe, Association, Originaux A, Séance 7 décembre 1868

according to Bennert, the difference in quality was not sufficient to justify such a large difference. In his opinion, increasing the price for Belgian glass would be reasonable.[615] This instance illustrates quite directly how important the price advantage must have been for the success of Belgian glass on foreign markets. Gwilliam visited Belgium again the following month. Discussing the huge price gap between English and Belgian glass on the English market, the *Association* once more agreed to an increase of the price of Belgian glass. During the same meeting, an interesting discussion on the differences in organisation of the window-glass industry in England and Belgium took place. According to Gwilliam, the English industry possessed five major advantages over its Belgian counterpart, namely:

1. There were only five 'glass masters' (glass manufacturers) in England, which made the reaching of agreement easier.
2. They (English glass masters) sold to the traders directly, without other intermediaries.
3. They sold in small batches of 15 to 20 crates at once.
4. The production of the 4th choice amounted to only one tenth of English consumption.

The interpretation of the last point (*Ils ne fabriquent en 4e choix qu'environ la dixième partie de la consommation de l'Angleterre*) is somewhat ambiguous, yet it seems to indicate that English manufacturers tended mainly to concentrate on the production of higher qualities.

During the same session, Bastin informed the *Association* about the current situation of the French glass industry. According to his information, given that the entire French production was consumed on the internal market, there was no reason to fear their competition on the London market at that moment. Gwilliam, for his part, promised to establish contacts with French manufacturers in order to engage them to increase their prices. This is the only case of an attempt towards coordination between more than two countries (Belgium, England and France). Yet, no further notices in this respect are recorded in the proceedings.[616] Curiously, five years later, the *Association* stated that it was exactly in 1873 that French started to dominate the London market.[617]

The cooperation with Gwilliam was not always successful. For example, when he proposed forming an *entente* for raising prices of the 4th quality in packages of 300 square feet on the London market in 1877, the *Association* politely declined.[618]

Nevertheless, the communication channel remained open. On some occasions, the *Association* showed more willingness to follow Gwilliam's propositions, as had been the case in December 1879 when, attending the meeting personally, Gwilliam asked Belgians to raise prices, following the British, who had already increased their prices by 33% in November. This time, the *Association* agreed and increased their price by 35%. Even more interestingly, this occasion presented the first evidence of a kind of coordination between the British and Belgian glass manufacturers on the 'third' markets. For instance, the prices for the Danish market were discussed. In general, Gwilliam assured the *Association* that Pilkington (the

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[615] Private archive Gobbe, Association, Originaux C, Séance 16 septembre 1873
[616] Private archive Gobbe, Association, Originaux C, Séance 30 octobre 1873
[617] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877
[618] Private archive Gobbe, Association, Originaux C, Séance 28 mai 1877

leading British glass manufacturer) was willing to maintain the same prices as the Belgians on the British as well as foreign markets. Because of this, the British were interested in the exchange of information with the Belgians on the state of various markets. The *Association* agreed to cooperate with the British in this respect. For instance, Gwilliam asked the Belgians to provide him with the prices 'that could be relevant for the North of France', although the exact interpretation of this demand is unclear (whether it concerned the prices on the French market, or prices of the French manufacturers).[619]

It is doubtful whether this kind of coordination on the 'third markets' should be regarded as a true international cartel, as no formal unambiguous regulation is preserved, at least not in the sources available for this study. Yet, we can at least catch a glimpse of a kind of 'gentleman's agreement'.

In almost all instances, the contacts between the Belgians and British took place via Gwilliam. The proceedings record only one single occasion upon which the *Association* dealt with any British manufacturer directly, viz. 1880, when Léon Mondron (then-president of the *Association*) discussed prices with Pilkington directly. While no details of these negotiations were recorded it must have concerned the continental European markets, providing one more indication of the existence of a sort of 'gentleman's agreement' between the Belgians and the British for the 'third markets'.[620]

The contacts and coordination measures between the *Association* and its British counterpart seems to have come to an end in the 1880s. In August 1883, Gwilliam's letter was read at the *Association*'s meeting.[621] In 1887, contact with Gwilliam was mentioned for the last time.[622]

Other countries

Apart from the British, contacts with colleagues from other countries were sporadic at best. Around 1872-1873, the *Association* tried to establish contacts with the German and French manufacturers, and even to form an *entente de chômage*, a kind of production-limiting, cartel-like agreement with the latter, yet without apparent results.[623] For instance, the session of 8 March 1873, where a possible *chômage* was discussed, was attended by the representatives of a 'French *comité*' (presumably a French organisation similar to the *Association*). The purpose of this delegation was described as preventing 'ruinous competition' (*concurrence ruineuse*). Apart from this, the French were interested in Belgian prices. Moreover, it was decided to send a Belgian delegation consisting of de Dorlodot, Hindel and Van der Elst (the *Association*'s secretary) to Cologne in order to attend a meeting of German manufacturers.[624]

Apart from these instances, the contacts with French manufacturers are mentioned only a couple of times during the period of the *Association's* existence. For example, at the session

[619] Private archive Gobbe, Association, Originaux C, Séance 17 décembre 1879
[620] Private archive Gobbe, Association, Originaux C, Séance 5 mai 1880
[621] Private archive Gobbe, Association, Brouillons II, Séance 11 août 1883
[622] Private archive Gobbe, Association, Brouillons II, Séance 1 octobre 1887
[623] Private archive Gobbe, Association, Originaux C, Séance 8 mars 1873, Séance 25 mars 1873
[624] Private archive Gobbe, Association, Originaux C, Séance 8 mars 1873

of 28 April 1880, the President read a report on prices, which had been composed by the 'French glass committee of the North' (*Comité verrier français du Nord*) at the request of de Dorlodot and Vander Elst.[625] Apparently, the French were willing to share this information with their Belgian competitors. Shortly afterwards, in May of the same year, the *Association* provided the French (designated as the *Syndicat des Maîtres de Verreries du Nord de la France* this time, quite probably the same as the aforementioned organisation) with the list of Belgian prices, upon their request.[626] The exchange of information about prices with the French was a two-way street apparently.

Some contacts with the French were recorded in 1889, albeit in a rather 'unfriendly way', when the *Association* tried to protest against French commercial practices. At that time, French manufacturers had formed a *syndicat* that regulated sales within France while allowing for full freedom on external markets. In this way, French could use the advantage of their vast domestic market to fight Belgian manufacturers on the international markets. This must have led to negotiations, as the *Association's* President received a visit from a Mr Wagrent and Mr Hayet (or Hayez, unclear writing), French glass manufacturers. No outcome of these negotiations was mentioned, however.[627] As a reaction to the French practice, L. Lambert proposed forming a *syndicat pour la vente en France*. Yet, no result of this initiative was recorded either.[628]

Outside these few contacts with French entrepreneurs, no contacts with colleagues from other countries are mentioned in the proceedings of the *Association*, except for efforts to acquire new technologies from German and American firms in the late 19th and early 20th centuries, which will be discussed in the part on technology. Nothing similar to the 'special relationship' and semi-permanent negotiations with the British (represented by Gwilliam) on the matters of mutual price coordination ever appeared for other countries.
In the late 1880s, a number of letters were exchanged with a certain Wallace King of Baltimore, an American glass manufacturer and, apparently, a representative of the American window-glass industry association, described as the *Association Nationale des Maîtres de Verreries Américaines* (National Association of American Glass Masters). This correspondence concerned one single issue only, namely, the unification of packaging tariffs.[629]

In 1909 the *Association* received a letter from the German window-glass manufacturers, proposing a kind of coalition (*entente*) between the manufacturers of both countries, aiming at the fixing of prices. However, the *Association* decided that such an arrangement, while based on 'justified and serious observations', was not possible formally. It was therefore decided to maintain contacts with German colleagues 'in an informal way'. Nothing was recorded on this issue afterwards, possibly precisely because of the informal nature. Hence, it is unknown whether this effort towards the establishment of an international cartel-like arrangement delivered any practical results.[630]

[625] Private archive Gobbe, Association, Brouillons I, Séance 28 April 1880
[626] Private archive Gobbe, Association, Originaux C, Séance 5 mai 1880
[627] Private archive Gobbe, Association, Originaux C, Assemblée Générale 15 mai 1889
[628] Private archive Gobbe, Association, Originaux C, Assemblée Générale 22 mai 1889
[629] Private archive Gobbe, Association, Brouillons II, Séance 4 avril 1887
[630] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 18 juin 1909

In general, during the entire period of coordination between the Belgians and the British (as represented by Gwilliam) between 1865 and 1887, the increase of Belgian prices remained the main point of discussion, indicating that low prices must have been the main Belgian comparative advantage on the British market. Interestingly, the higher qualities (1st and 2nd) were never mentioned, which suggests that Belgians specialised in middle- and lower quality glass (3rd, 4th and *coarse*), at least on the British market.

<u>International activities and the 'American crisis'</u>

As already noted in the introduction, the development of the American window-glass industry started to pose a real threat to the Belgian manufacturers from approximately 1880 onwards. In 1884-1885, the developments in the United States, alongside some other factors, led to a true 'American crisis' in Belgium. Reacting to this challenge, the *Association* strengthened its international activities of various kinds, including some not recorded before. Hence, the instance of the 'American crisis' provides an interesting case in this respect, as it illustrates how a regional organisation such as the *Association* could engage in international matters, not only 'passively' (by acquiring information) but even 'actively' (by trying to influence the policy of foreign countries). This shows both the extent as well as the limits of the *Association*'s agency.

The provision of information on the situation in America, including the state of American industry as well as labour relationships and conflicts (strikes), seem to have been regarded as an issue of utmost importance by the *Association*. Articles from the American press were read and discussed at the *Association's* meetings on multiple occasions.[631] Information on the situation in America was communicated by members themselves as well, quite probably (although no sources were mentioned) originating from their trade agents or other contacts there.[632] As mentioned previously (see the section on the coordination of production), the information on the American situation was decisive for the elaboration of a common strategy and appropriate measures, such as *chômage*, on the part of the *Association*.

The acute situation caused by the 'American crisis' led to the intensification of contacts between the *Association* and consuls as well. For instance, on 16 February 1884, the *Association* discussed a letter sent by Reuleaux, a Belgian General Consul in Philadelphia, on the state of the American glass industry.[633] In November 1885, Reuleaux participated in the *Association's* meeting personally, sharing his opinion on the situation of the American window-glass industry. According to him, it was experiencing a crisis at that moment, but he expected a new 'era of prosperity' in the future. While the American window-glass industry was expanding, consumption was expanding as well. Therefore, Reuleaux believed there were still opportunities on the American market for Belgian manufacturers. However, according to Reuleaux, the developments of the American customs policy would be decisive for the accessibility of the American market for Belgian manufacturers. This is the only recorded case of a Belgian consul attending the *Association's* meeting personally.

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[631] Private archive Gobbe, Association, Brouillons II, Séance 27 juillet 1885
[632] Private archive Gobbe, Association, Brouillons II, Séance 21 mars 1884
[633] Private archive Gobbe, Association, Brouillons II, Séance 16 février 1884

During the same meeting, Reuleux had discussed the result of the 'Exposition of New Orleans'. There is not much doubt that he was referring to the World's Industrial and Cotton Centennial Exposition of 1884. In his opinion, the results were very satisfying, as the Belgian products had been highly appreciated. However, it would take some time to establish direct relationships (with New Orleans and, presumably, the entire Southern United States). Previously, Belgian glass had been imported via New York, where it had often been labelled as French. However, according to Reuleux, the 'fortunate effect' of the exposition would be to familiarise local clients with the Belgian products, which had often been received previously under false marks of origin.

Concluding his speech, Reuleux proposed that the *Association*'s members provide him with their prices as well as information on their means of production and specialisations, as he would translate this information and supply it to the (American) importers.[634]

It is interesting to compare the opinion expressed by Reuleux with American sources. One guidebook to the exposition speaks of 'glass goods, fine display' when describing the Belgian exposition.[635] Another guidebook mentions Belgian glass without any details.[636] The reception of Belgian glass by Americans seems to have been a little less enthusiastic than implied by Reuleux.

While the 'American crisis' engendered a kind of intensification of 'international strategies' of the *Association* on other occasions before and after, a completely new and unique strategy was recorded on this occasion as well. It concerns a kind of international lobbying aimed at the American customs policy. In fact, the American market proved to be a 'battlefield' in the 1880s, even before the acute outbreak of the 'American crisis'. In 1882, Mr S. Bache urged the *Association* to engage in a campaign aiming to reduce American import duties. The action used to achieve this end were the publication of articles of various newspapers and the organisation of conferences. The *Association* supported this proposition unanimously, and decided to provide a subsidy of ten thousand Belgian francs.[637] On other occasions, the same correspondent was designated as *maison Bache* (*maison* standing for house, meaning trading house in this context) in New York. Without much doubt, *maison* Bache refers to the firm of Semon Bache (1826-1891), a Jewish immigrant from Fürth (near Nuremberg, Bavaria), who moved to the United States and established a trading house *Semon Bache & C°* in New York in 1847, specialised in mirrors and other types of (mostly luxury) glass.[638]

The issue remained relevant for at least a few years, as in 1884 the *Association* provided a 'subsidy' for an American customs reform that amounted to five thousand Belgian francs, still in cooperation with *maison Bache*. According to the proceedings, the 'subsidy' was 'used' successfully in the US Congress. Unfortunately, no detail was provided on precisely what this

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634 Private archive Gobbe, Association, Brouillons II, Séance 14 novembre 1885

635 Daniel W. Perkins, *Practical Common Sense Guide Book through the World's Industrial and Cotton Exposition at New Orleans* (Harrisburg, PA: Lane S. Hart, 1885), 59.

636 Herbert S. Fairall, *The World's Industrial and Cotton Centennial Exposition, New Orleans, 1884-1885* (Iowa City, Ia: Republican Publishing Company, 1885), 401.

637 Private archive Gobbe, Association, Originaux C, Séance 13 février 1882

638 Henry Hall, ed., *America's Successful Men of Affairs. An Encyclopedia of Contemporary Biography*. Vol 1 (New York: The New York Tribune, 1895), 52.

'use' implied.[639] The long-term success of this operation is in any case debatable. As already described in the introductory part, the American tariffs as well as the development of domestic American industry basically removed Belgian window-glass manufacturers from the American market by the late 19th century, save for some specialised products. Nevertheless, the effort is worth mentioning as it illustrates the business ties between the *Association* and foreign partners.

Much later, in 1908, the trading house *Lemon, Bache & C°* of New York, possibly the successor of Semon Bache, contacted the *Association* asking for a 'subsidy' of ten to twenty thousand Belgian francs to campaign against the proposed increase of import duties on 'certain qualities' of window glass. However, this time the *Association* refused to grant the subsidy. Possibly, it already regarded the American market as largely lost by that time.[640] It is known that *Lemon, Bache & C°* of New York indeed submitted petitions against the increase of duty on glass to the United States Congress in 1909.[641]

Association: conclusion

The *Association* acted as both a BIA in the present-day sense and a cartel organisation. As the former, its functions included maintaining various international contacts, collaboration with the Government (especially in the context of international trade, exploration of new markets, and international promotion), measures taken for the provision of fuel and raw materials, and measures for the improvement of transport conditions, among other things. In particular, the *Association*'s role in the development of technology and innovation will be discussed in detail in Part 3, Chapter 3.2. As for the latter, it acted as a framework for the organisation of temporary cartel-like arrangements, related to the limitation of production and the coordination of sales primarily. Up to 1890 approximately, the limitation of production (*chômage*) was most often employed. After 1890 the *chômage* almost disappeared, while various arrangements regarding the regulation of primarily international trade (*conventions*) became much more numerous. Undoubtedly, this was a consequence of the tightening of international competition, as evidenced by the almost desperate attempt to 'fight' for the American market. Institutionally, the *Association* evolved towards a more formalised, centralised and professionalised structure more or less along the lines described by van Waarden for the (Dutch) BIAs in general.

The establishment of the *Association* predated the emergence of the organised labour movement by several decades; therefore, it can certainly not be seen as a reaction to the labourers' demands, as is often assumed in the older literature (yet already disproved by Vanthemsche). Nevertheless, the development of the labour movement certainly strengthened the *Association*, especially after 1880 when the resistance to labourers' 'unreasonable demands' became the main focus of the *Association*'s activities. Yet, the tightening of international competition seems to have provided an even earlier stimulus for closer cooperation within the *Association* from the 1880s on, if not earlier.

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639 Private archive Gobbe, Association, Brouillons II, Séance du 9 février 1884
640 Private archive Gobbe, Association, Originaux D, Assemblée Générale du 30 novembre 1908
641 *Congressional Record-House of Representatives*, vol. 44 – part 2, 9 April 1909, p. 1307.

Rhetorically, the *Association* strongly adhered to liberal principles. In practice, however, the liberal non-interventionalist principles were undermined by the aforementioned *chômages, conventions* and other arrangements that certainly limited free competition. By the early 20th century, the need (or even urgency) for even tighter cooperation (such as the *Trust des Verreries Belges*) due to increasing international competition was widely acknowledged. However, the individualistic attitudes of some members made this kind of closer cooperation within the *Association* very difficult, if not impossible. On the other hand, the liberal principles led to resistance to protectionism on international markets. This is not surprising given the very export-oriented character of the industry. Yet, as far as the cooperation between firms within Belgium was concerned, a much more pragmatic attitude could be observed. Reaching an agreement was often problematic, and many such *chômages* and *conventions* failed, yet it was not a taboo either.

The role of human resource management (i.e. opposition to labourers' demands) was an important area of the *Association*'s activity as well. As noted previously, it increased with the emergence of the organised labour movement from the 1880s on. In the early 20th century, the role of labour became even more apparent primarily in the context of the *Convention* of 1902-1904, that led to interesting discussions. It appeared from this case that the pool of specialised glassblower labour defined the limits of the industrial district to a large degree. By that time, most of the *Association's* members regarded as desirable the closer cooperation within this district (i.e. excluding a few firms located outside, such as *Verreries de Binche*).

The 'dissident' firms that opposed various cooperation arrangements, were either the largest first (such as *Bennert & Bivort*) or those located outside (*Binche*, *Jemappes*) or at least externally (*Mariemont*) in relation to the centre of the industrial district (*Jumet*, *Lodelinsart*). The opposition of the former category of 'dissidents' can be explained by the fact that larger firms, which had more of their own resources, were less dependent on cooperation with others. It is hardly a coincidence that the *Association* united small firms originally, while larger ones, such as *Bennert & Bivort*, only joined later. The position of the latter category of 'dissidents', those located externally, was defined by their position in relation to the labour market. As they were not dependent on the 'floating' labour market (labourers that could easily move from one factory to another within the core of the district), these firms were not inclined to follow the common human resource policy, as implied by the *Convention* of 1902-1904 for instance. Hence, the limits of the labour pool were to a large degree a defining factor for the cooperation between firms.

It can therefore be argued, speculatively, that the *Association* could have achieved much better results as a governing body had it limited its membership to the firms within the district. In a way, the *Association* became a victim of the overstretch, that is, expanding its reach beyond the 'natural' area of the industrial district.

Last but not least, the international dimension developed by the *Association* is truly remarkable. As already noted by Georges de Leener, the deficient knowledge of the state of markets proved to be a great handicap for many Belgian industries.[642] As will be shown in the

[642] De Leener, *L'organisation syndicale des Chefs d'industrie*, vol. 2, 64.

following pages (of the present chapter and elsewhere in the thesis), this was not the case for the *Association* and, hence, the entire window-glass industry. Looking back at the theory of Bathelet, Malmberg and Maskell (local 'buzz' and global pipelines, see Part 1, Chapter 1.1), the *Association* had created nothing short of a global pipelines network.

The Institutional framework of (primarily international) trade and promotion

As noted above, the role of international trade cannot be overestimated for such an export-oriented industry as window glass. From the institutionalist point of view, the foreign trade policy as conducted by the Belgian state can be seen as an important institution as well. This 'trade policy' will be interpreted broadly here. Alongside trade treaties, the role of the consular network will be considered as well.

Obviously, the fact of it being a national institution cannot explain the concentration of the window-glass industry within a small region. Nevertheless, it is worth considering for two reasons. First, as the window-glass industry was very export-oriented, the conditions of access to foreign markets were extremely important. This was also true for Belgian industry in general, because, lacking a large domestic market, it relied heavily on exports. The Belgian government realised the vital role of international trade for the economic development of Belgium and engaged in active policy in this respect. Second, as will be discussed further, there was an intensive interaction between the national officials (consuls first and foremost) that represented the national foreign trade policy and the *Association* in the latter part of the 19th century. This provides an interesting example of interaction between institutions on different levels (national and local).

Foreign trade policy of the Belgian government

First and foremost, the general position of Belgium on the international market should be considered. As noted by Paul Bairoch, the 'small countries' of Europe (defined by him as Belgium, Bulgaria, Denmark, Finland, Greece, the Netherlands, Norway, Portugal, Romania, Serbia, Sweden and Switzerland) presented a stronger rate of growth of international trade during the 19th century than the 'large countries'. This became especially apparent between 1860 and 1910. During this period, the annual growth rate of exports from 'small countries' amounted to 3.7%, while for the 'large countries' this figure was only 2.6% (with the United Kingdom) or 2.7% (without the United Kingdom). The more active participation of 'small countries' in international trade can be attributed to various reasons. With the course of industrialisation, 'small countries' had to import an ever-growing range of goods, as they were unable to produce all new types of commodities themselves due to their limited size. In order to balance their trade, they had to increase their exports as well. The lack of raw materials was another incentive for 'small countries' to engage in international exchange more actively.[643] However, it could be argued that this factor was of lesser importance for Belgium, as it possessed important deposits of raw materials, such as coal, despite its modest size.[644]

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[643] Bairoch, *Commerce extérieur et développement économique*, 258-260.
[644] David S. Landes, *The unbound Prometheus. Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge: Cambridge University Press, 1969), 176, 216.

Hence, being unable to produce the whole range of 'modern' commodities, and lacking sufficient raw materials in many cases as well, 'small countries' tended to follow the path of specialisation, which allowed them to find their niche on international markets alongside 'large countries'. Bairoch distinguished two strategies in that respect. First, he pointed to the 'complementarity strategy', which was mostly imposed by the lack of raw materials. Here, the 'small countries' acted as economically complementary to the United Kingdom and, to a lesser extent, other 'large' industrialised countries. As the relative price of agricultural products increased in the industrialised countries, 'small countries' following this strategy could gain a relative advantage by specialising in supplying 'large' industrialised countries with foodstuffs and other agricultural products or other non-industrial goods, such as wood. In return, they could acquire industrial goods. This strategy was followed by Denmark, Portugal, Norway, Finland and, partly, Sweden. The 'competition strategy' implied engagement in competition on international markets with the United Kingdom and, to a lesser extent, other 'large' industrialised countries by 'small' countries, whereby they relied on some key raw materials or 'industrial traditions' (*traditions industrielles*, as Bairoch puts it). Belgium and Switzerland followed this strategy, while Sweden largely switched from the 'complementarity strategy' to the 'competition strategy' in the late 19th century. It should be noted, however, that the pursuit of the 'complementarity strategy' did not necessarily imply economic backwardness. For instance, Denmark succeeded in developing a modern economy despite following the 'complementarity strategy'. Yet, generally, 'small countries' following the 'competition strategy' presented stronger rates of economic growth when compared to both 'complementary small countries' as well as 'large countries'.[645]

The Belgian rate of exports grew steadily throughout the entire 19th century. From a total in the early 1840s of about 7–10% of Gross National Product (GNP), by 1899-1901, exports had reached 36% of GNP. And by 1900, Belgium had reached the highest rate of exports in Europe per capita or as a share of GNP, effectively making it the most export-oriented economy at that time.[646]

Alongside the purely quantitative growth, the scope of Belgian exports, considered as both the number of destinations as well as the range of products exported, expanded strongly in the second half of the 19th century. Between approximately 1870 and 1910, the number of destinations (countries) grew from around 35 to 70, while the number of types of exported products increased from about 80 to 170.[647]

It should come as no surprise, therefore, that Belgium followed the largely free-trade policy (*libre-échangisme*) throughout the 19th century. It had already negotiated bilateral trade agreements with the United Kingdom and the Netherlands before the Cobden–Chevalier treaty between France and the United Kingdom, which marked the general turn towards free trade in Europe in 1860. After the Cobden–Chevalier treaty, Belgium had signed various trade treaties, the most important being those with France in 1861, the United Kingdom in 1862,

[645] Bairoch, *Commerce extérieur et développement économique*, 260.
[646] Bairoch, *Commerce extérieur et développement économique*, 270-273.
[647] Huberman et al., "Technology and Geography," 50-51.

the Netherlands in 1863, and Prussia in 1865.[648] A very modest turn towards protectionism emerged after 1887, however.[649]

The general direction of the foreign trade policy, if regarded as an institution, was heading towards the promoting and facilitating of exports. This was to the advantage of the very export-oriented window-glass industry, as well as other primarily export-oriented sectors. To provide just a few examples, in 1913 the export percentage amounted to 61% for the ceramics industry, 80% for marble quarries, 83% for the automobile and motorcycle industry, 88% for the glass industry, 91% for the zinc industry, 92% for the nickel industry and 98% for the flax industry. Even the industries that did not engage in export, such as electricity power stations, depended on export indirectly, as they acted as suppliers for the export-oriented industries. The dependence of the Belgian economy on exports was expressed in a then often-used expression 'Export to live' (*Exporter pour vivre*).[650]

The Belgian government took various measures towards this goal. In economic terms, these measures aimed at lowering fixed and 'beachhead' costs for gaining a foothold and introducing (new) products on foreign markets (the term 'beachhead' refers to the strategy of gaining a small market segment first and expanding it thereafter[651]). These included gaining knowledge of local market conditions, establishing various networks, and so forth. In some respects, Belgium found itself at a disadvantage vis-à-vis large colonial empires such as the United Kingdom and France, as it lacked colonial export markets (Belgium's only colony, Congo, absorbed only 2% of Belgian exports before the Second World War[652]). Nor could it rely on large communities of immigrants that could act as 'agents', helping to establish business networks and promote Belgian products in foreign countries, as was the case for Italy. With the help of diplomatic efforts, Belgium succeeded in securing an advantageous position within the international community, despite these disadvantages. As already mentioned, Belgium actively established trade treaties with various countries. To this can be added active participation in international networks of other kinds, such as those concerning labour and science. In general, Belgium presented itself as an open and non-aligned (neutral) country. In addition, the country hosted multiple international fairs in the late 19th and early 20th century.[653]

Of particular importance was a network of Belgian consuls that was expanded in the second half of the 19th century. Around the middle of the century, it was limited to the neighbouring countries mostly, but by 1870 Belgian consuls were to be found on all continents. By 1900, the number of Belgian consuls amounted to six hundred, stationed in 84 independent countries or colonies, more than half of these locations being outside Europe. Some of these consuls were in fact foreign nationals, yet they acted as Belgian representatives. The Belgian government invested large amounts of money in this network, with expenses for the consuls

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[648] Michael Huberman, "Ticket to trade: Belgian labour and globalization before 1914." *The Economic History Review*, new series 61, no. 2 (May 2008): 330.
[649] Bairoch, *Commerce extérieur et développement économique*, 271.
[650] Van De Velde, "De Staat en de organisatorische uitbouw van de Belgische buitenlandse handel," 1173.
[651] John F. Mahon and Sushil Vachani, "Establishing a beachhead in international markets – A direct or indirect approach," *Long Range Planning* 25 no. 3 (June 1992): 60-69.
[652] P. Bairoch, *Commerce extérieur et développement économique*, 272.
[653] Huberman et al., "Technology and Geography," 42-47.

and other representatives rising from 0.6 million Belgian francs in 1860 to 1.5 million Belgian francs in 1890.[654]

One of the important functions of these consuls was the provision of information. They regularly sent their reports to Belgium, where they were published in a special official publication called the *Recueil consulaire*. The reports published in the *Recueil consulaire* provided valuable information on the state of foreign markets, tariffs, transport and other facilities, consumer preferences and so forth. The value of this information, which was provided to the Belgian manufacturers, merchants and other entrepreneurs by the Belgian government is hard to overestimate.[655] Yet, as will be shown later (see the chapter on the international activities of the *Association*), apart from delivering reports to the government, Belgian consuls maintained direct contacts with Belgian industrialists, sometimes even delivering useful information on request.

Moreover, the Belgian government stimulated economic activities in foreign countries by establishing a financial infrastructure, the *Banque Belge pour l'Étranger* being one of the most important examples in this respect. The bank, originally called *Banque Sino-Belge*, was established in 1902 upon the initiative of the Belgian King, Leopold II. As the name suggests, the original goal was to finance Belgian economic activities in China. Yet, later, branches were established outside China in Europe and Africa.[656]

However, the situation of the Belgian foreign trade presented a number of important deficiencies, which were not adequately met by the Belgian foreign trade policy. For instance, in most cases, this trade had effectively been conducted by foreigners. Even in Antwerp (thus, Belgium itself), the majority of trading houses were owned by foreigners, while a large share of Belgian exports was conducted by commission centres in Paris, London, Hamburg and New York. The number of Belgian commercial (as opposed to diplomatic) representatives in foreign countries remained minimal as well.[657]

The Belgian banking and finance sector, while strongly developed within the country, remained underrepresented abroad with a few exceptions, such as the *Banque Italo-Belge* and *Banque Belge pour l'Étranger*. Therefore, the Belgian export was largely financed by German banks. Last but not least, the Belgian merchant fleet remained rather modest. By 1913, it amounted to 123 ships (350,000 ton) only.[658]

This situation had multiple negative consequences. For instance, the fact that the largest share of the Belgian export trade was conducted by foreigners often caused the 'anonymisation' of trade, as foreign consumers were, in fact, often unaware of the Belgian origin of commodities. This caused a loss of 'representation' and 'brand' value of Belgium.[659]

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[654] Ibidem, 46.
[655] Ibidem, 46.
[656] State Archives of Belgium. Finding aid. *Inventaire des archives de la B.B.E. (Banque Belge pour l'Étranger) puis Compagnie belge pour l'Étranger et ses filiales 1902-1977* (Brussels: State Archives of Belgium, n.d.), 8-9.
[657] Van De Velde, "De Staat en de organisatorische uitbouw van de Belgische buitenlandse handel," 1174-1175.
[658] Ibidem, 1175-1176.
[659] Ibidem, 1176.

Hence, it may be concluded that while the Belgian export trade was strongly supported by government policy, the commercial organisation remained deficient in most cases.

The interaction between the Association, the Belgian Government, the consular network and other international agents

The *Association* played an important role in the functioning of the institutional framework of the Belgian international trade (such as the consular network), as established by the Belgian government. The *Association*'s proceedings provide an important source in this respect, informing us about the scope of this institutional framework managed by the Belgian government (for instance, the location of Belgian consuls and the services they provided to the window-glass industry) as well as the role played by the *Association* itself.

The first 'international' activities of the *Association* were of an indirect nature, and involved the drafting of petitions related to international issues, which were addressed to various national governmental bodies. One of the earliest examples was a petition addressed to the Chamber of Representatives in 1851, demanding the maintaining of a trade treaty with the Netherlands.[660] In 1860, a petition was addressed to the Ministry of Foreign Affairs, asking it to take window glass into consideration during the negotiations for the renewal of a trade treaty with France.[661] In 1863, the *Association* decided to thank the Ministry of Foreign Affairs for the new trade treaty with Italy, which lowered import duties for Belgian window glass from 8 to 7 Belgian francs (it is not clear why two numbers were provided) to 5 Belgian francs per 100 kg starting from 1 August 1864. Expressing its gratitude, the *Association* 'expressed the hope that [the government] would proceed along the way of commercial liberty.'[662]

It is not known whether this adjustment of duties was a direct result of the *Association*'s lobbying. At any rate, the word of thanks clearly expressed the *Association*'s main objective on the question of international trade. As a strongly export-oriented industry, it wished for the lowering of customs barriers, supported free trade and opposed protectionism. At the same time, being dependent on imports of many raw materials, the *Association* directed many requests and petitions to the government in relation to the import duties on sodium sulphate, wood for crates, and coal, as discussed in more detail in the chapters on raw materials and fuel.

The government was not always attentive to the interests of the glass industry, however. For instance, when a new trade treaty with Portugal was elaborated by the Ministry of Foreign Affairs in 1864, the *Association* drafted a petition reminding the Ministry that the interests of the glass industry had been forgotten in the recent treaties with Switzerland and Spain, and asked for the acknowledgment of the interests of this industry on this new occasion.[663]

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[660] Private archive Gobbe, Association, Originaux A, Séance 2 décembre 1851
[661] Private archive Gobbe, Association, Originaux A, Séance 21 janvier 1860
[662] Private archive Gobbe, Association, Originaux A, Séance 7 juin 1863. Quote: "avec espoir que l'on continuera à marcher dans la voie de la liberté commerciale"
[663] Private archive Gobbe, Association, Originaux A, Séance 6 février 1864

Curiously, despite the 'special relationship' and even a certain degree of cooperation that the *Association* maintained with its English counterpart (see further on in this chapter), some issues still had to be settled on the diplomatic front. In 1881, the *Association* and the Charleroi Chamber of Commerce directed a letter to the Minister of Foreign Affairs, demanding that the Belgian government put more pressure on the English government in the context of 'ongoing negotiations', although the exact nature of these negotiations is unclear. It seem to have concerned a trade treaty with France in one way or another. The exact details as well as the role of the English in these matters are unclear.[664]

In general, the Ministry regularly informed the *Association* on current developments, in particular the situation regarding foreign trade and custom tariffs. For example, at the *Comité* session of 5 February 1880, three letters from the Ministry were read out: one concerning trade with Naples, one on the custom tariff with the Zollverein and one on the custom tariff with Denmark.[665]

As the exact details on the information provided by the Ministry to the *Association* are almost never mentioned explicitly, it is difficult to judge how exclusive this information was. However, on one occasion in 1893, the proceedings explicitly mentioned the 'documents provided confidentially' by the Ministry of Foreign Affairs. These documents concerned a project on customs reforms in Canada.[666]

The *Association* maintained contacts with Belgian consuls all over the world. The first occurrence that can, tentatively, be interpreted as a direct contact between the *Association* and a Belgian consul or other official representative abroad took place in 1873, when the president informed the assembly on his conversation with a certain Mr De Groot in Japan. The president had sent to De Groot specimens of Belgian glass as well a list of all members of the *Association*. As Mr De Groot was described as a 'Minister resident in Japan' (*Ministre Résident au Japon*), it is unclear what his exact function (consul or otherwise) was. At any rate, this is the earliest recorded case of contacts between the *Association* and (presumably) a Belgian official abroad. Moreover, the fact of the exchange of specimens clearly indicates that Mr De Groot helped to promote Belgian window glass in this distant country.[667]

The contacts between the *Association* and Belgian consuls rapidly intensified from the late 1879 onwards. At first, these contacts were 'semi-direct', as the consuls' communications were transferred to the *Association* by the Belgian Ministry of Foreign Affairs. This was the case in December 1879, when the *Association* received from the Ministry a report from the Belgian consul in Constantinople on the state of commerce in Turkey.[668] In February 1880, the Ministry transmitted a letter from the consul in Naples, advising all manufacturers to exercise the utmost prudence when choosing 'correspondents' (most probably, trading agents) in Southern Italy.[669] In 1880, the *Association* received a report from a consul in Serbia on the commercial situation in this country, although it is not clear whether it was

[664] Private archive Gobbe, Association, Originaux C, Séance 14 juin 1881
[665] Private archive Gobbe, Association, Brouillons I, Séance 5 février 1880
[666] Private archive Gobbe, Association, Originaux C, Assemblée Générale 12 mai 1893
[667] Private archive Gobbe, Association, Originaux C, Séance 16 septembre 1873
[668] Private archive Gobbe, Association, Originaux C, Séance 17 décembre 1879
[669] Private archive Gobbe, Association, Originaux C, Séance 11 février 1880

transmitted directly from the consul or via the Ministry.[670] At any rate, the mentions of consuls and the information they provided started to become truly numerous after 1880. While the list of consuls that appear in the *Association's* proceedings is long, some examples are worth mentioning in order to give an idea of the geographical scope, as well as issues treated.

While the correspondence between the *Association* and consuls is not preserved, some proceedings mention the information exchanged briefly. For example, in 1880, the Belgian consul in Tiflis (Russia, present-day Tbilisi, Georgia) provided information on the situation of some local entrepreneurs (possibly, clients or potential clients) that were active there. For example, if the consul was to be believed, a certain Arten Aahverdoff (sic, the original spelling used in the proceedings did not do justice the, presumably, Georgian name) enjoyed good solvency, while the solvency of Artem Gregoire Mivreloff (sic, the same remark) was rather questionable. Moreover, the consul provided useful information on some (presumably Russian) firms that had representatives (called *correspondents*) in Europe. For instance, *Banque du Crédit mutuel* was represented by *Crédit Lyonnais* in Marseille and *Banque de Commerce* by a certain Frank Model in Brussels.[671] It is not entirely clear whether the *Banque du Crédit mutuel* and *Banque de Commerce* were local Russian firms or not, nor does it really matter in the context of the present study. What does matter is the fact that the *Association* could rely on detailed (possibly even exclusive) information about local affairs due to a Belgian consul. If consuls failed to provide useful information, the *Association* could require clarification. This was apparently the case when the consul in Yokohama failed to provide useful information in his report. The *Association* replied to the consul by indicating which pieces of information it wanted to receive.[672]

Information on the organisation of trade was provided by consuls as well. For example, writing in 1881, the Belgian consul at Zanzibar informed the *Association* that the trade with this locality was conducted through Hamburg, Liverpool and Marseille.[673]

Consuls informed the *Association* about the state of the glass industry and commerce in their countries of residence as well, providing insights that must have been quite valuable for the direction of policy vis-à-vis foreign competitors on international markets. For example, in 1882, the Belgian consul in Saint-Petersburg provided the *Association* with statistics on glass commerce in Russia.[674] At the same time, information on the situation of the American window-glass industry, including strikes and labour conflicts, was provided regularly by the Belgian consuls in Philadelphia and New York from the last decades of the 19th century on.[675] In 1884, a Belgian consul in Sunderland provided the *Association* with information about glassblowers' wages in this city, an important centre of the English glass industry.[676] While not going into too much detail, it can be mentioned as well that the *Association* received communications from consuls in Beirut and Yokohama in 1882[677].

[670] Private archive Gobbe, Association, Originaux C, Séance 5 mai 1880
[671] Private archive Gobbe, Association, Brouillons I, Séance 24 septembre 1880
[672] Private archive Gobbe, Association, Brouillons I, Séance 17 octobre 1881
[673] Private archive Gobbe, Association, Brouillons I, Séance 26 novembre 1881
[674] Private archive Gobbe, Association, Originaux C, Séance 14 janvier 1882
[675] Private archive Gobbe, Association, Brouillons II, Séance 8 février 1884, Séance 19 novembre 1886
[676] Private archive Gobbe, Association, Brouillons II, Séance 2 mai 1884
[677] Private archive Gobbe, Association, Originaux C, Séance 13 février 1882, Séance 15 mai 1882

It can be concluded that, thanks to the information received from Belgian consuls as well from other sources, the *Association* was well informed about the state of the glass industry and commerce in the most important competing countries and consumer markets. This allowed the *Association* to set prices accordingly and decide on other policies, such as *chômage*, wages and so on.

The information exchange between the *Association* and consuls was not a one-way street either. On another instance, at the *Association* session of 17 October 1881, a letter from the Ministry was read out, which asked the *Association* what kind of information it wished to receive from Belgian consuls.[678] In fact, the *Association* even advised the Ministry on the nomination of consuls. For example, in 1881, it recommended the nomination of a certain Mr Fredencier (no first name mentioned) as a consul at Smyrna (Ottoman Empire, present-day Izmir, Turkey).[679] Other instances of a two-way communication between the *Association* and the Ministry can be given. For instance, the Ministry informed the *Association* on the state of negotiations concerning trade treaties and similar arrangements with other countries, as was, for example, the case for Turkey in 1883 (*convention commerciale*).[680] The role of consuls could extend to that of pure informants as well. While consuls informed the *Association* about the state of local markets and affairs in general, they also acted as representatives of the Belgian window-glass industry, providing information to local clients. For example, a consul in Constanta (Romania) asked the *Association* to provide price list and trade conditions in 1881, undoubtedly in order to inform local (potential) clients.[681]

The list of examples could be extended, but it must already be clear how tight the cooperation between the *Association* and Belgian consuls was. Without the intermediary of the *Association*, it is quite doubtful whether most of the window-glass manufacturers, with the possible exception of the largest firms, could have maintained such a worldwide information network. Yet, for such an export-oriented industry, access to information must have been of the greatest importance.

It is interesting to note, however, that the contacts between the *Association* and the consular network became much less frequent from the late 1880s on. This could be attributed to the fact that many manufacturers had established their own contacts in foreign countries by that time, as is suggested by the multiple mentions of foreign 'agents' of various kinds (see the chapter on the organisation of trade). It seems, therefore, that the role of the consular network was most important during a relatively short period between the late 1870s and late 1880s. On the other hand, it could be attributed to the whims of record-keeping as well. For example, on one occasion in 1897, the proceedings just mentioned briefly 'a series of communications with consular corps related to the trade in window glass' without any details, while previously the content of individual consular communications had at least been mentioned in the proceedings.[682] Moreover, in a report on the state of the window-glass industry in 1913, the *Association* mentioned quite explicitly that 'we can count on very

[678] Private archive Gobbe, Association, Brouillons I, Séance 17 octobre 1881
[679] Private archive Gobbe, Association, Brouillons I, Séance 30 mai 1881
[680] Private archive Gobbe, Association, Brouillons II, Séance 1 juin 1883
[681] Private archive Gobbe, Association, Brouillons I, Séance 26 novembre 1881
[682] Private archive Gobbe, Association, Originaux C, Assemblée Générale 19 novembre 1897

dedicated, if not very effective, support from our consular corps and the Ministry of Foreign Affairs.'[683]

Between 1908 and 1909, the *Association* became involved in the establishment of the *Banque Belge à Londres*. First, the Belgian consul informed the *Association* about this bank project in 1908, while the *Association's* president presented the great advantages of this institution for export commerce to the members. Although the *Association* could not participate in this project directly, members were encouraged to subscribe individually.[684] The *Banque Belge à Londres* almost certainly implied a London branch of the *Banque Belge pour l'Étranger*, as this branch was established in 1909.[685]

Contacts outside the Belgian diplomatic network were sought as well. For example, at the *Comité* session of 3 May 1879, Tock, the representative of the *Verreries de Mariemont*, expressed his wish to find anyone who could prepare a report on the situation in Australia, making it clear that the *Comité* was actively gathering information about the situation of promising markets.[686] Sometimes contacts are mentioned by name, while their function (consul or otherwise) remains unclear. For example, at the *Comité* session of 13 August 1879, a report from a certain Mr Bruyssel on the situation in Mexico was read out.[687] In 1879, the *Association* received a letter from a certain Mess A&C Zunz (possibly, a trading agent or intermediary), urging the Belgian manufacturers to lower prices for Canada, as this market was under threat of being taken over by the English. The letter was 'taken into consideration'.[688]

In summary, the *Association* interacted actively with the Belgian Government in the context of the institutional framework of Belgian foreign trade. The consuls provided the *Association* with useful information, while acting as industry representatives and even trading agents at the same time on some occasions. Hence, this case presents us with a fine example of the mutually beneficial interaction of institutions on different levels (national and regional) and belonging to different frameworks (foreign trade policy as conducted by the national government and a voluntarily business interest organisation). From the perspective of the theory of industrial districts, this illustrates how the *Association* could 'plug into' the networks of 'pipelines' (the consular network primarily) established by the Belgian government. This provides a useful extension to the original thesis of Bathelt, which considered the establishment of 'pipelines' by individual firms only. Yet, as appears from our example, regional business interest organisations such as the *Association* could also perform this function effectively. This can be regarded as an additional externality (agglomeration effect), as a larger organisation had more resources for the establishment of 'pipelines' than individual firms. The 'tapping into' the network of 'pipelines' established by the national government is a new element as well.

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[683] Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913. Quote : "nous pouvons compter sur un appui très dévoués, sinon très efficace, de notre corps consulaire et du Ministère des Affaires Étrangères"
[684] Private archive Gobbe, Association, Originaux D, Assemblée Générale 30 novembre 1908; Assemblée Générale 18 juin 1909
[685] State Archives of Belgium. Finding aid. *Inventaire des archives de la B.B.E.,* 8-9.
[686] Private archive Gobbe, Association, Brouillons I, Séance 3 mai 1879
[687] Private archive Gobbe, Association, Brouillons I, Séance 13 août 1879
[688] Private archive Gobbe, Association, Originaux C, Séance 25 août 1879

International promotion and representation, exploration of new markets

The Belgian government played an important role in the activities related to the international promotion and representation of the Belgian industry, as well as the exploration of new markets. Here, the (international) industrial exhibitions, trade missions and even the establishment of 'commercial museums' were employed as the main 'tools' for achieving this goal.

The history of industrial expositions stretches back to the mid-18th century. In 1756-1757, the Society of Arts of London offered prizes for examples of production of various industries, such as tapestry, textiles and porcelain, whereby the specimens were put on public display. This is often regarded as the first industrial exposition. The first national industrial exposition in France was held in Paris in 1798. After 1819, the organisation of industrial expositions became widespread throughout Europe, and the 19th century witnessed a real boom in reginal, national and international industrial expositions, aiming at the promotion of industry and other economic activities. In 1851, the well-known Great Exhibition was held in London, being the first of a series of international exhibitions known as world fairs.[689]

Belgium did not lag behind in this respect. Between 1835 and 1883, eight national industrial expositions were held in Belgium, alongside some regional and specialised expositions dedicated to specific industries, such as textiles. Subsequently, Belgian representatives participated in most, if not all world fairs, while eight world fairs were organised in Belgium itself before the First World War, viz. in Antwerp (1885), Brussels (1888), Antwerp (1894), Brussels (1897), Liège (1905), Brussels (1910), Charleroi (1911) and Ghent (1913). The Belgian government supported Belgian participants at foreign world fairs and played a key role in the organisation of world fairs (as well as other industrial expositions) in Belgium.[690]

In addition, in the course of the 19th century, the Belgian government organised multiple trade missions aiming to gain information on the state of foreign markets as well as to establish direct trade relationships. Another means towards the facilitation of trade undertaken by the government was the establishment of the so-called 'commercial museums'. The purpose of these establishments was to promote commerce as well as to collect objects (samples of commodities) and information relevant for commerce. They were, therefore, distinct from the present-day museum concept, functioning rather as information offices. A *Musée Commercial de l'État* was established in Brussels in 1882. It possessed an exposition of the samples of commodities, while functioning as an information office at the same time.[691] As will be shown later, commercial museums were established (or at least attempted to be established) by the Belgian government in foreign countries as well.

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[689] *Official Descriptive and Illustrated Catalogue* of the *Great Exhibition of the Works of Industry of all Nations, 1851* (London: Spicer Brothers, 1851), Vol. 1, 1-2.

[690]Albert Michielsen, *De evolutie van de handelsorganisatie in België sedert het begin der 18*[de] *eeuw* (Turnhout: J. Van Mierloo-Proost, 1938), 324-327; Bracke, *Bronnen voor de industriële geschiedenis,* 323-324; State Archives of Belgium. Finding aid. *Inventaire des archives du Ministère de l'Industrie et du Travail. Expositions universelles, internationales, foires, congrès et salons (Partie I), 1860-1932.* (Brussels: State Archives of Belgium, n.d.), 42-44.

[691] Michielsen, *De evolutie van de handelsorganisatie in België*, 288-289.

Hence, the international promotion of Belgian industry was actively pursued by the Belgian government. Nevertheless, the *Association* played a key role in this regard as well. The following paragraph will show how the interaction and collaboration between these two institutions (the Belgian government on the national scale and the *Association* on the regional) helped to promote Belgian window glass on the global market, while revealing specific attitudes related to the international representation of the Belgian window-glass industry as well.

To begin with the world fairs and other exhibitions, it can be established that the *Association* participated in most, if not all, world fairs from 1851 on, as well as some 'local' and specialised expositions in Belgium and foreign countries. Some examples can provide interesting insights into the mentality of manufacturers. In 1872, the president actively encouraged all members to participate in the forthcoming Vienna World Fair in order to form a 'collective exhibition'.[692] In a similar vein, during the discussion about the participation at the 1878 Paris World Fair, it was decided to make a 'collective exposition', representing the Belgian window-glass industry as a whole. The formulation is worth quoting: 'Morel expresses an idea, to organise a collective exposition, within which individualities would disappear, while the reward would be allocated to the Belgian glass industry [underlined within the document – V.V.].'[693] This indicates that the *Association* wanted to represent 'Belgian window glass' as a unified brand. Moreover, the decision to organise a collective exposition by the *Association* testifies to the common identity among the manufacturers within the district, even though it was designated as 'Belgian' and not 'Charleroi'.

Collective participation at international fairs occurred on many occasions over the years. For example, preparing for the Antwerp World Fair of 1885, it was decided to participate as a 'glass collectivity' (*collectivité verrière*), clearly indicating a kind of common identity.[694] The same principle was adopted in preparation for subsequent expositions, such as the Chicago Fair (World's Columbian Exposition), held in 1893 and the International Exposition of Ghent in 1913.[695]

It appears, therefore, that despite the individualism of many firms, a 'collective identity' was regarded as advantageous for promotion on the international market.

Quite obviously, the participants at World Fairs strove to promote their products, attract new clients and even open up entire new markets. For instance, a report by the Charleroi Chamber of Commerce mentioned that the Belgian window-glass industry succeeded in attracting new orders from clients in Austria and Romania thanks to the 1873 Vienna World Fair.[696]

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[692] Private archive Gobbe, Association, Originaux B, Séance 11 juin 1872

[693] Private archive Gobbe, Association, Brouillons I, Séance 16 février 1877. Quote: "Morel émet l'idée d'organiser une exposition collective, dans laquelle les individualités dispairent à la récompense qui serait accordée à la verrerie belge"

[694] Private archive Gobbe, Association, Brouillons II, Séance 22 octobre 1884, Séance 20 avril 1885

[695] Private archive Gobbe, Association, Originaux C, Assemblée Générale 11 décembre 1891; Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913

[696] Chambre de commerce de Charleroi. *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1873*, 56.

And yet, the participation in World Fairs and other international exhibitions was not a trivial matter. While it assured international promotion, it could present a certain danger too, as participants needed to share sensitive information. In some cases, this could entail threats of industrial espionage as well. Apparently, this is exactly what happened at the 1876 Philadelphia World Fair, better known as the Centennial International Exhibition, as attested to by a long and eloquent letter composed by Fourcault-Frison, and addressed by the *Association* to the Ministry of Internal Affairs (a copy of the letter had been recorded in the proceedings). While no names were mentioned, and despite the generally polite tone, the content of the letter clearly indicated huge discontent on the part of the *Association*. The letter stated that all members of commissions and juries of the exhibition, be they paid or unremunerated, should be competent, professional, and, in the first place, loyal to the country and industry in order to avoid a kind of 'Sad scandalous spectacle that had outraged the commercial and industrial world of entire Belgium.'[697] Apparently, some (unnamed) member of a Belgian jury had acted as if he were an American rather than Belgian mandatory. In one way or another, this 'hero' had caused great harm to the Belgian glass industry, which could even have led to a complete closure of the American market for the Belgian glass industry, while simultaneously seducing the best Belgian glass workers to emigrate to America. Unfortunately, it is not known exactly what happened, as the letter used rather vague formulations. In conclusion, the letter required the Minister to allow the industrialists to designate their representatives for the exhibition commissions and juries themselves, or at least to have more say in the appointments of such functionaries by the government. This is an interesting remark from the institutional point of view, as it shows how a local institution (the *Association*) desired to acquire more control at the expense of the national institution (the Belgian government).

While the letter did not mention the exact content of the scandal, it alluded to the fact that such functionaries had access to very sensitive information on the part of manufacturers, although, again, no specific details were mentioned. It appears, therefore, that something of such information, related to the window-glass industry especially, had been 'stolen' by a Belgian jury member and 'shared' with Americans to their advantage. Ironically, this may have involved an instance of technology transfer. Hence, despite their importance as a means of international promotion, the international exhibitions presented a very real threat of undesirable disclosure and industrial espionage.[698] Nevertheless, the *Association* was still willing to participate in the American International Expositions, such as the 1884 New Orleans World's Industrial and Cotton Centennial Exposition.[699] Apparently, the potential gains (promotion, getting customers acquainted with Belgian products directly) outweighed the potential dangers (industrial espionage).

Apart from temporary expositions, the *Association* also collaborated in the establishment of the so-called 'Samples' Museum in Shanghai' (*Musée d'échantillons à Shanghai*) around 1878-1879, undoubtedly a kind of a 'commercial museum' as mentioned above. While not many details on this project were provided, it seems to have been conceived by the Ministry

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[697] Private archive Gobbe, Association, Originaux C, Séance 8 janvier 1877. Quote: "triste spectacle du scandale qui a indigné le monde commercial et industriel de la Belgique entière"
[698] Private archive Gobbe, Association, Originaux C, Séance 8 janvier 1877
[699] Private archive Gobbe, Association, Brouillons II, Séance 14 novembre 1885

of Foreign Affairs as a permanent or semi-permanent exposition of Belgian industrial products, intended as an instrument of promotion at the Chinese market. Here, again, the *Association* decided to participate in the form of a 'collective exposition', presumably in order to promote its common identity. Unfortunately, the fate of the project is not clear,[700] but even if this project was eventually not realised, the engagement of the *Association* testifies to the active international promotion policy, especially when promising emergent markets, such as China, were concerned.

About twenty years later, in 1899, a new initiative to strengthen economic ties with China was recorded within the proceedings. At that opportunity, the *Association's* President Emile Fourcault introduced Mr Duckerts, a General Consul, who was preparing 'a mission of exploration and studies' (*une mission d'exploration et des études*) in China. The main objective of this mission was the establishment of Belgian trading houses and banks in China, as well as the organisation of regular transport between Antwerp and China. Discussing the present situation, the *Association* representative informed Duckerts that the sales of Belgian glass in China occurred through English and German trading houses. The *Association* was largely satisfied with this situation, as the intervention of these foreign intermediaries did not cost much. Nevertheless, the *Association's* president expressed interest in the aims of the proposed mission. In particular, the establishment of *comptoirs* (sales agencies) and other (Belgian) financial and economic services was regarded as desirable by the *Association*. Moreover, seeing that other glass-related industries, such as the manufacturers of mirror glass (*glacerie*) and crystal (*cristallerie*) were already participating in the project, the *Association* judged that the window-glass industry could not lag behind, and decided to support the mission financially by providing a subsidy of 2,500 Belgian francs.[701]

Some *Association* members seem to have been engaged in other arrangements aimed at representation in foreign countries. For instance, in 1889 the president encouraged members to participate in the *Comptoir Belgo-Canadien* more actively as, at that moment, only one manufacturer (*L. de Dorlodot & C°)* had been represented in that body.[702] This consortium of 14 Belgian companies was established in 1888 by Ferdinand van Bruyssel, a Belgian General Consul in Montréal, in order to supply Central Canada with glass, rails, cement, and to provide technical expertise on railway construction and other public works.[703]

As already noted above, the *Association* made use of its contacts with Belgian consuls (as well as with other official and non-official representatives) to gather information on promising and emerging markets. In some cases, the 'conquest' of new markets had been stated as an explicit goal. For instance, in 1884, the Ministry of Industry asked the *Association* to assist a certain Mr Hanen (his exact function is unknown) on his 'exploration voyage' (*voyage d'exploration*) to New Zealand. The *Association* decided to provide him with a set of specimens of Belgian glass, at the *Association's* own cost.[704]

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[700] Private archive Gobbe, Association, Brouillons I, Séance 18 décembre 1878 and 13 août 1879
[701] Private archive Gobbe, Association, Originaux D, Assemblée Générale 27 janvier 1899
[702] Private archive Gobbe, Association, Brouillons II, Séance du 14 janvier 1889
[703] Cornelius J. Jaenen, "Belgian Canadians," The Canadian Encyclopedia, published online 2 April 2009, last edited 2 February 2018, accessed 14 June 2022 https://www.thecanadianencyclopedia.ca/en/article/belgians
[704] Private archive Gobbe, Association, Brouillons II, Séance 22 octobre 1884, Séance 15 décembre 1884

On one occasion in 1889, the Ministry of Foreign Affairs asked the *Association* to provide six sets (*collections*) of samples for the industrial schools in Hungary. While, unfortunately, no further details of this curious instance were provided, it could be interpreted as a means of international promotion as well, providing the Hungarian students with examples of Belgian production. The *Association* decided to fulfil the request.[705]

To these activities, the participation of *Association* members at various international conferences can be added. The earliest instance was recorded in 1881, when an organising committee invited the *Association*'s President to participate at the *Congrès Commercial & Industriel à Liège*.[706] Later the same year, the Secretary presented his report of this congress to the *Association*.[707] Unfortunately, the report itself is not preserved. It is not exactly known what kind of congress, but possibly, it was the *Congrès International des Entrepreneurs*, held in Liège in July 1881.[708]

In 1889, the president encouraged members to participate in the Berlin exposition, dedicated to the 'safety systems and devices, used in factories in the interest of labourers, as measures directed to their well-being'.[709] Without doubt, this must have been the *Deutschen Allgemeinen Ausstellung für Unfallverhütung*.[710] This is one of the very few (if not the sole) instances whereby the *Association* showed any interest in the workers' well-being.
All in all, the close collaboration between the *Association* and the Belgian government is evident from the examples discussed in this section. It can therefore be concluded that the goals of international promotion were achieved through the interactions of two institutions acting at two different levels: the Belgian government (the Ministry of Foreign Affairs in particular) at the national level and the *Association* at the regional level.

The institutional framework of logistics and transports

While the general outline of the development of transport infrastructure has already been provided (Part 1, Chapters 1.2 and 1.3), the present paragraph will focus on the role played by various institutions, national and regional as well as public and private, in the context of transport and logistics. As already discussed, the railway and maritime transport was the most important for the window-glass industry. Apart from the transport of glass itself, the dominant role of these modes of transport for the provision of fuel and raw materials is evident from Chapter 2, Chapter 2.1 on location factors. As discussed there, coal was transported by railway, while maritime transport assured the provision of English sulphate.

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705 Private archive Gobbe, Association, Originaux C, Assemblée Générale 23 décembre 1889
706 Private archive Gobbe, Association, Brouillons I, Séance 30 mai 1881
707 Private archive Gobbe, Association, Brouillons I, Séance 5 août 1881
708 Jelena Dobbels, Inge Bertels and Ine Wouters, "The professionalization of Belgian general contractors (1877-1914): an analysis of the construction journal La Cronique des Travaux Publics, du Commerce et de l'Industrie," in *Further Studies in the History of Construction. The Proceedings of the Third Annual Conference of the Construction History Society, Cambridge, 8-10 April 2016,* eds. James Campbell et al. (Cambridge: The Construction History Society, 2016), 309-320.
709 Private archive Gobbe, Association, Brouillons II, Séance 14 janvier 1889
710 *Deutsche Allgemeine Ausstellung für Unfallverhütung Berlin 1889: Ausstellung für Industrie, Bergbau, Baugewerbe, Landwirtschaft, Schiffahrt, Verkehrsgewerbe etc. aus den Gesichtspunkten der Unfallverhütung, der Gewerbehygiene und der Wohlfahrt der Arbeiter; Katalog* (Berlin: Carl Heymanns Verlag, 1889)

In general, the Belgian government (especially the Liberals) endeavoured to keep the transport tariffs for the industry (for raw materials as well as industrial products) as low as possible. Nevertheless, the industrialists tended to complain that the government's transport policy did not support them sufficiently.[711]

Hence, we will consider the role of the Belgian government as well as the *Association* (and, in some cases, other actors as well) in maritime as well as railway transport.

Maritime transport

During the 19th century (as today) the port of Antwerp was the most important gateway of Belgium, connecting it to the entire world. The port infrastructure underwent major developments in the course of the century, as new docks were constructed.[712] It seems, however, that these developments were largely defined by the city authorities rather than by the Belgian government. While the government certainly collaborated in the development of the port, it was the city authorities that took the initiative.[713]

The Belgian government did not play an important role in the logistics of maritime transport either. In some instances, it provided support for the Belgian shipping companies, yet these subsidies had little influence on the situation. In 1895, a shipping company *Société Maritime du Congo* (the present-day *Compagnie maritime belge*) was established upon the initiative of Leopold II in cooperation with an English shipping company. As indicated by the name, it primarily served the 'free state' and later Belgian colony of Congo, and was therefore of no notable importance for the window-glass industry.[714] Undoubtedly, the most important intervention of the Belgian government in maritime affairs was the agreement with the Dutch for the abolition of the Scheldt tolls in 1863.[715]

On a few occasions, maritime transport had been brought to the *Association*'s attention. In 1860-1861, the establishment of a direct steamship line between Antwerp and the United States was discussed. The *Association* was very much in favour of this project, deeming it to be of great use not only for industry and commerce, but also for the 'public interest' in general. According to the *Association*, the great potential usefulness of such a project even justified a state subsidy. Moreover, the *Association* emphasised that all port duties (quay duties, pilotage duties) should be kept as low as possible to ensure Antwerp's advantage over other ports, while the custom tariffs should be kept 'as liberal as possible'. Interestingly, the *Association* noted that direct navigation should be established with both the northern as well as the southern United States. Seizing the opportunity, the *Association* expressed its desire to reduce the transport (railway) tariff between Leuven and Antwerp.[716] We do not know who the initiator of this project was, nor do we know anything about the outcome. It was

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[711] Vanthemsche, *De paradoxen van de Staat,* 77-78.
[712] Albert Himler, "De Antwerpse haven vanaf de Franse periode," in *Antwerpen, een geschenk van de Schelde. De Antwerpse haven door de eeuwen heen,* ed. F. De Nave (Brussels: Gemeentekrediet van België, 1993), 33-47.
[713] *Anvers port du mer. Description du port et des établissements maritimes d'Anvers* (Brussels: Guyot, 1885), 82-97.
[714] R. Baetens and A. De Vos, *Antwerps maritiem verleden* (Antwerp: MIM, 1990), 53-58.
[715] Himler, "De Antwerpse haven," 39.
[716] Private archive Gobbe, Association, Originaux A, Séance 22 septembre 1860, Séance 6 mars 1861

probably negative though, as in 1864 the American Council of Brussels (*Conseil Américain de Bruxelles*) contacted various Belgian Chambers of Commerce in order to ask for support for a regular steamship line between Antwerp and the United States, which had been elaborated by an American firm. The *Association* was asked, and agreed, to show its support for the project alongside the Chambers.[717] Just as in the previous case, the outcome is unknown. Nevertheless, it can be assumed that the *Association* was regarded as an important actor by the American initiators of the project.

In 1867, a representative of the trading house *Hetter & Cie* (possibly Hittin, or Hiller, as the name is almost unreadable) approached the *Association* with his project for the establishment of a steamship connection between Antwerp and New York in collaboration with the private railway company *Grand Central Belge,* whereby the transport of glass would be assured directly from Belgian railway stations to New York. The *Association* showed no interest in this proposal, as various trading houses in Antwerp already offered cheaper transport to America.[718]

Port infrastructure in Antwerp came to the *Association's* attention once in 1881, when it established the poor condition of the quay where the steamships for America were loaded and allocated a sum of two hundred Belgian francs to a surveyor in order to study installations in the new port of Antwerp. No further information on this project was recorded afterwards.[719] Hence, the *Association* did not play any active role in the development of maritime transport. Yet it had been approached by various shipping companies and other organisations in this context, proving that it was at least regarded as an important (potential) partner and stakeholder.

One maritime-related topic that did feature prominently within the *Association*'s proceedings over the years, was transport security in the port of Antwerp, or, as it appears, the lack of it.

It seems indeed that the port of Antwerp had a particularly bad reputation in this respect. If we are to believe remarks exchanged at the *Association* meetings, improper treatment of crates and even theft were endemic there, while the local authorities did not do enough to remedy the situation. During a discussion of this problem in July 1881, the *Association*'s president mentioned 'innumerable abuses' that were taking place in Antwerp. In order to improve the situation, it was decided to appoint someone as an *Association* agent to permanently monitor the treatment of cargoes of glass in Antwerp, and report on the irregularities.[720] Shortly after, it was decided to announce a vacancy for this position in Antwerp journals. The wage offered was three hundreds Belgian francs per month.[721] Interestingly, according to Léopold de Dorlodot, the 'ability to speak Flemish' was regarded as one of the prerequisites for the position.[722] The task of an agent, also described as

[717] Private archive Gobbe, Association, Originaux A, Séance 24 octobre 1864
[718] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1866
[719] Private archive Gobbe, Association, Brouillons I, Séance 30 mai 1881
[720] Private archive Gobbe, Association, Originaux C, Séance 16 juillet 1881
[721] Private archive Gobbe, Association, Originaux C, Séance 8 août 1881
[722] Private archive Gobbe, Association, Brouillons I, Séance 22 août 1881

‘surveillant’, consisted of visiting quays ‘attentively’ and reporting to the *Association* on the situation.[723]

Apparently, the offer attracted many candidates.[724] Eventually, a certain Mr Lebeau was chosen by the *Association* for this position in October 1881.[725] Acting as the *Association*’s agent in the port of Antwerp, Lebeau directed his efforts towards the prevention of thefts primarily. In August 1883, the *Association* awarded him with a premium (*gratification*) of 500 Belgian francs for the (unspecified) measures he had taken for the prevention of theft. On top of that, he received one hundred Belgian francs to be used as a ‘gift’ for the Antwerp chef of police for his help with surveillance of the situation in the port. Moreover, the *Association*’s president reported on the requests made by the *Association*’s delegation before the Mayor of Antwerp, demanding the engagement of police with the surveillance of the loading and treatment of glass in the port. Apparently, collaboration was promised by the Mayor.[726]

Apart from the treatment of shipments of glass in the port, Lebeau kept his eye on other transport movements related to the *Association* as well. For instance, in 1883 he reported on a certain ‘reclamation’ concerning the transport of sulphate by the State Railways (no further details were provided).[727] On another occasion in the same year, Lebeau reported on the question of an indemnity to be paid by the State Railways for the constant breakage of glass upon arrival (in Antwerp). The Railways were prepared to pay for all previous cases, but in future the *Association* had to draw up a reclamation for every new case. It was decided to send a commission to Brussels to discuss this problem with the Minister of Public Works.[728]

In 1885, Lebau was replaced by Ducoffre. The new agent was hired through a job advert in local newspapers. His yearly wage amounted to 2,500 Belgian francs.[729] By 1886 Ducoffre’s field of action was extended to include the port of Ghent as well. For instance, in December 1886, he informed the *Association* about the poor treatment of cargoes of glass there.[730] He clearly kept a close eye on glass-related criminal activities as well, as he informed the *Association* about the condemnation of glass thieves in Antwerp by letter in November 1887. In the same letter, he asked for permission to get a telephone subscription, which was granted by the *Association*.[731] Apart from theft, Ducoffre informed *Association* about other forms of fraud and abuse in the ports of Antwerp and Ghent. Apparently, shipping agents (*expéditeurs*) in Antwerp tried to ‘hide the breakage’ in one way or another, when the loading had been ‘deficient’ in Ghent (*embarquements déficieux*).[732] Yet, despite all efforts, the ‘theft problem’ in the port of Antwerp remained (or even worsened) over the years, and in 1889 Ducoffre requested the *Association’s* permission to employ ‘helpers’ (aides) and even

[723] Private archive Gobbe, Association, Brouillons I, Séance 17 octobre 1881
[724] Private archive Gobbe, Association, Originaux C, Séance 20 octobre 1881
[725] Private archive Gobbe, Association, Originaux C, Séance 8 décembre 1881
[726] Private archive Gobbe, Association, Brouillons II, Assemblée Générale du 11 août 1883
[727] Private archive Gobbe, Association, Brouillons II, Séance 24 septembre 1883
[728] Private archive Gobbe, Association, Brouillons II, Séance 26 octobre 1883
[729] Private archive Gobbe, Association, Brouillons II, Séance 20 avril 1885, Séance 15 mai 1885
[730] Private archive Gobbe, Association, Brouillons II, Séance 17 décembre 1886
[731] Private archive Gobbe, Association, Brouillons II, Séance 7 novembre 1887
[732] Private archive Gobbe, Association, Brouillons II, Séance 5 décembre 1887

an authorisation to bear arms.[733] Numerous thefts in the port of Antwerp were discussed again in 1893 on multiple occasions.[734] The situation in the port of Ghent was not much better than in Antwerp, and Ducoffre regularly reported on the 'lack of care when loading glass' there as well. The *Association* even decided to send a delegation of L. Monnoyer and Em. Thilimans to Ghent in order to establish the facts and compile a report.[735]

Despite the usefulness of the services provided by Ducoffre, which was acknowledged by the *Association* itself, it was decided to terminate this position from 1895 on for reasons of economy. For instance, for the budget of 1894, the expenses for the 'agent in Antwerp' (Ducoffre) amounted to 2,565 Belgian francs out of the total yearly expenses of 5,550 Belgian francs.[736]

Railway transport

Development of physical infrastructure

The engagement of the *Association* with the development of physical infrastructure remained rather limited and sporadic. As noted in the chapter on raw materials, the *Association* supported the demand for the relocation of the Tilly railway station in 1856 and again in 1863 in order to improve the access by rail to the Tilly sand pits.[737] It is not known whether these demands resulted in any concrete results, however.
The only example of the *Association*'s active engagement with the development of the physical transport infrastructure concerns the construction of a railway line from La Planche to Marchiennes in the region of Charleroi around 1863 by the State Railways of Belgium. The *Association* actively supported the project and wished it to be executed as quickly as possible. In order to strengthen support, it decided to draw up a petition and organise a special gathering with other stakeholders of the region, in particular the President and Secretary of the Chamber of Commerce, owners of metallurgy enterprises (including the *Société de Providence* of Monceau), owners of foundries and coal mines, as well as local politicians such as the mayors of the communes of Dampremy, Marchiennes and Monceau.[738] It is not exactly clear which railway was meant. The (now closed) station Dampremy La Planche was already served by railway (the present-day line Ottognies–Marcinelle) from 1855 on.[739] Possibly, the industrial line Monceau–Charleroi Ouest (line 260) was meant, as it corresponds roughly to the described direction (see map from Railations.net, already presented in Part 1, Chapter 1.5).[740]

In 1867, the *Grand Central Belge*, wishing to acquire a concession for the construction and exploitation of a railway line from Marchiennes (presumably; place name illegible) to

[733] Private archive Gobbe, Association, Originaux C, Assemblée Générale 23 décembre 1889
[734] Private archive Gobbe, Association, Brouillons III, Assemblée Générale, 17 février 1893
[735] Private archive Gobbe, Association, Brouillons II, Séance 31 août 1888
[736] Private archive Gobbe, Association, Originaux C, Assemblée Générale 2 mars 1894
[737] Private archive Gobbe, Association, Originaux A, Séance 12 avril 1856, Séance 28 octobre 1863, Séance 10 décembre 1863
[738] Private archive Gobbe, Association, Originaux A, Séance 4 mars 1863, Séance 7 juin 1863, Séance 4 septembre 1863
[739] Belgische spoorlijnen, "Lijnen 111-120"
[740] Railations, "Van Jumet-Brûlotte naar Marchenne-Est"

Brussels, asked for the *Association*'s support. The *Association* decided to attest its support for the project to the government, yet it expressed the desire for the new railway to branch off the existing *Grand Central Belge* railway in Fleurus instead of in Marchiennes.[741] It is known that *Grand Central Belge* received a permission for the construction of an industrial line between its mainline and Marchiennes in 1873, but it is unclear to what degree this project took into account the *Association's* desires.[742]

The railway infrastructure features for the last time in the *Association*'s proceedings in 1869, when the delay in the construction of a railway line between Châtelineau and Luttre (further in the direction of Brussels) had been addressed. According to the discussion, the works should already have been started in July 1866, yet the concessionaries seemed not to have been fulfilling their obligations. The *Association*'s decided to address a petition to the Minister of Public Works, requiring the works to be resumed promptly.[743] Possibly, this referred to the Châtelet–Luttre line (line 119), although it was only completed between 1876 and 1880 (in sections).[744]

<u>Tariffs and transport conditions</u>

Unlike the previous issue, the questions of tariffs and transport conditions was a semi-permanent concern for the *Association*. The first petition to the railway administration demanding the 'adjustment' (quite obviously, reduction) of tariffs for the transport of glass had already been addressed in 1857.[745] New requests for the reduction of tariffs for the transport of glass as well as for coal from the region of Mons and other raw materials had been addressed by the *Association* in 1859, 1864, 1879, 1885, 1887.[746] For instance, in 1864, the *Association* addressed a petition to the Minister of Public Works demanding the reclassification of window glass from the second to the third category in the new railway tariffs.[747] The petition was not successful, as window glass remained within the second category. Despite this defeat, the *Association* asserted that it would keep pushing for the adjustment of transport tariffs.[748]

More examples for the petitions and other demands for the reduction of tariffs on the transport are to be found in the chapters on the provision of fuel and raw materials.

In most cases, it is unknown whether these petitions achieved any results. Given the fact that they were submitted repeatedly, the effect must have been limited at best. Yet on some occasions clear 'victories' were achieved. As was the case in 1864 when the Secretary informed the members that the tariffs adjustment had been achieved from both the State Railways as well as from the *Grand Central Belge*. Here, he stated explicitly that this

[741] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1867
[742] Morue, "Le Grand Central Belge," 71.
[743] Private archive Gobbe, Association, Originaux A, Séance 23 septembre 1867
[744] Belgische spoorlijnen, "Lijnen 111-120"
[745] Private archive Gobbe, Association, Originaux A, Séance 15 septembre 1857
[746] Private archive Gobbe, Association, Originaux A, Séance 10 décembre 1859, Séance 1 juin 1864, Originaux C, Séance 12 mai 1879, Originaux C, Séance 25 août 1879, Brouillons II, Séance 27 juillet 1885, Brouillons II, Séance 4 avril 1887, Brouillons II, Séance 6 mai 1887
[747] Private archive Gobbe, Association, Originaux A, Séance 6 février 1864
[748] Private archive Gobbe, Association, Originaux A, Séance 1 juin 1864

adjustment could only have been achieved thanks to the active involvement of the bureau (of the *Association*) and Mr Bennert (of the *Bennert & Bivort* firm), marking a clear case of successful lobbying. At the same time, tariffs for the transport of sand and lime had been 'declassified' by the State Railways and reduced by the *Grand Central Belge*.[749]

Apart from semi-permanent complaints and petitions, the *Association* engaged in direct negotiations with the railway companies as well. In particular, a special committee appointed by the *Association* for these ends, and consisting of members P. Hindel, Fr. Schmidt and C. Lambert-fils, had negotiated with the *Grand Central Belge* on the question of new tariffs in 1868. Unfortunately, it is unclear to what degree the *Association's* members had been able to influence the new tariffs. They were defined after the negotiations as follows:

- <u>4th category (coal, etc.)</u>
    - Up to 15 *lieues* (*lieue* equals five km): tariffs of the State (presumably, State Railways)
    - 15 to 30 *lieues*: 15 centimes by ton-*lieue* (State: 10 centimes)
    - 31 *lieues* and more: 10 centimes by ton-*lieue*

- <u>3rd category (window glass – export)</u>
    - Up to 15 *lieues*: tariffs of the State
    - 15 to 30 *lieues*: supplement (*majeration*) of 20 centimes by ton-*lieue* (State: 15 centimes)
    - 31 to 60 *lieues*: supplement (*majeration*) of 15 centimes by ton-*lieue*
    - For Rotterdam: special tariff

- <u>2nd category (window glass)</u>
    - Up to 15 *lieues*: tariffs of the State
    - 15 to 30 *lieues*: 30 centimes by ton-*lieue* (State: 20 centimes)
    - 31 to 60 *lieues*: 20 centimes by ton-*lieue*

- <u>1st category</u>
    - Up to 40 *lieues*: tariffs of the State

Although incomplete (not all reference State tariffs are provided), this tariff at least makes it clear why the *Association* wished to reclassify glass as a third rather than a second category. Another point of discussion between the *Association* and *Grand Central Belge* concerned the minimum shipping volume. *Grand Central Belge*, just like the State Railways, proposed the minimum weight of a shipping of 10 ton, to make it eligible for the 3rd category exportation tariff. The *Association* wished to lower this minimum to 5 ton.[750] In particular, the *Association* justified this wish by remarking that the minimum weight of 10 ton would place 'small transport agents' (*les petits expéditeurs*) at a disadvantage in relation to 'large transport agents'.[751]

This is an interesting point, and allows us to draw some conclusions. While the transport tariffs were negotiated collectively between the *Association* and the *Grand Central Belge*, the

[749] Private archive Gobbe, Association, Originaux A, Séance 24 octobre 1864
[750] Private archive Gobbe, Association, Originaux A, Séance 11 mai 1868
[751] Private archive Gobbe, Association, Originaux A, Séance 8 juin 1868

logistics of transport and trade seem not to have been conducted in a centralised or monopolistic way; as the previous example implicitly shows, various transport and/or trade agents were active. The fact that the *Association* wished to keep the minimum shipment as low as five tons indicates that there were multiple small agents active, who traded in (relatively) small quantities of glass.

In 1868, the *Association* succeeded in negotiating the reduction of transport tariffs for glass with the *Grand Central Belge* from 1 January 1868 onwards, whereby the tariff for the transport of export-destined glass from Lodelinsart to Antwerp was reduced to the same level as required by the State Railways, that being 6.65 Belgian francs (presumably, per 1,000 kg). At the same time, the question of the lowering of minimum shipment weight from 10,000 kg to 5,000 remained open.[752]

The demands for the lowering of transport tariffs became much less frequent, albeit not totally absent, after approximately 1870. For instance, the *Association* had demanded the Minster of Railways to lower tariffs for the transport of glass as well as coal from Mons in 1887. The request was rejected by the Minister, however.[753]

Foreign railway tariffs were discussed as well, albeit not on a regular basis. In 1886, Mr Didier (no first name mentioned), a commercial agent of the French *Compagnie des Chemins de fer du Nord*, informed the Association about the new tariff that included reduction for the transport of glass to Paris. Moreover, Mr. Didier invited Belgian industrialists to inform him about other reforms of tariffs and transport conditions that they regarded as desirable. During the discussion on this matter, L. de Dorlodot noted that deliveries for Switzerland via Geneva could be carried out by the *Compagnie des Chemins de fer du Nord* as well.[754]

In addition to tariffs, transport conditions were also discussed quite often, as the service offered provoked multiple complaints. The first instance in this respect was recorded in 1865, when the *Association* complained about the lack of rolling stock for the transport of raw materials and glass at both the State Railways as well as *Grand Central Belge*, drafting a petition to the Minister of Public works demanding a solution to this problem.[755] It seems that, generally, *Grand Central Belge* caused more complaints than the State Railways, as more complaints explicitly related to the former were recorded on several occasions, for example in 1867.[756]

Also in 1868, the Charleroi Chamber of Commerce decided to join forces with various industrial organisations of Charleroi (associations of coal mining and metallurgy were also invited to participate) in order to study the complaints relating to the services provided by the State Railways. The main complaint of the *Association* for this joint commission was the minimum shipping weight. Just as in the case of *Grand Central Belge*, the *Association* wished to lower it from 10 to 5 ton. The transport conditions as offered by the State Railways were regarded as inadequate as well. Apparently, the State Railways often transported glass in

[752] Private archive Gobbe, Association, Originaux A, Séance 7 décembre 1868, Séance 28 décembre 1868
[753] Private archive Gobbe, Association, Brouillons II, Séance 4 avril 1887, Séance 6 mai 1887
[754] Private archive Gobbe, Association, Brouillons II, Séance 19 novembre 1886
[755] Private archive Gobbe, Association, Originaux A, Séance 16 octobre 1865, Séance 24 novembre 1865
[756] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1867

non-covered *wagons sans bâche*). In cases where such deficient transport was offered, the *Association* wished the tariffs to be lowered according to the 4th category.

Last but not least, the question of the construction of a new railway line from Châtelineau to Brussels via Luttre, already mentioned in the previous section, was addressed.[757]

Interestingly, this is one of only a few occasions where the active role of the Charleroi Chamber of Commerce is mentioned. However, this can also be ascribed to the fact that the sources of the Charleroi Chamber of Commerce could not be studied extensively within the framework of the present research.

The lack of covered cars for the transport of glass was recorded for *Grand Central Belge* as well. It appears that in 1868 various station masters of *Grand Central Belge* demanded transport agents (*expéditeurs*) to sign 'certificates of non-responsibility' (*certificats de non responsabilité*) in cases where glass was sent in non-covered wagons. This actually devolved employees of responsibility for the shipment of glass in inadequate conditions. The *Association* condemned such practices, requiring *Grand Central Belge* to use covered wagons for the transport of glass only. If uncovered wagons were used, the *Association* would demand the lowering of tariffs to the 4th category instead of the 3rd. It was decided to negotiate on the issue further with Jules Urban, a representative of *Grand Central Belge.*[758] The lack of covered wagons remained a 'hot topic' in the relationship between the *Association* and *Grand Central Belge* for quite some time. By 1869, Jules Urbain declared that he could not allow the declassification of glass to the 4th category if transported in non-covered wagons, yet he assured the Association that *Grand Central Belge* had ordered 500 tarpaulins in order to resolve the problem.[759]

The 'transport question' remained a source of concern for Charleroi industry in general for quite some time. In 1871, the organisation of colliery industrialists of Charleroi (*Comité Charbonnier de Charleroi*) arranged a common gathering with the representatives of the metallurgical and glass industries to address this problem. The general lack of rolling stock (rail cars) was reported by all participants. The glass industry specifically, as represented by the *Association*, complained about the high tariffs for the transport of glass as compared to other industrial products. For instance, while the tariff for the transport of glass to Antwerp was 6.50 Belgian francs per ton, the tariff for cast iron (*fonte*) was only 3.50 Belgian francs. Last but not least, L. Baudoux complained that wagons used to transport sulphate and *planchettes* (wood for crates) had ordinarily been offered for the transport of glass without being sufficiently cleaned, requiring the glass manufacturers to clean them themselves.[760]

The shortage of rolling stock seems to have been a nationwide problem circa 1871, as the issue was discussed by all Belgian Chambers of Commerce in Brussels. The *Association*, represented by its President, participated in this gathering at the invitation of the Charleroi Chamber of Commerce.[761] However, thereafter the question largely disappears from the

[757] Private archive Gobbe, Association, Originaux A, Séance 8 octobre 1868
[758] Private archive Gobbe, Association, Originaux A, Séance 7 décembre 1868
[759] Private archive Gobbe, Association, Originaux A, Séance 13 décembre 1869
[760] Private archive Gobbe, Association, Originaux A, Séance 23 janvier 1871
[761] Private archive Gobbe, Association, Originaux B, Séance 30 octobre 1871

Association's agenda. In 1878, the shortage of covered wagons, as well as demands for some specific tariff adjustments were addressed to *Grand Central Belge*, although it remains unclear whether these demands were successful.[762]

The question of railway tariffs resurfaced quite suddenly and in all seriousness in 1891, when a disagreement between the *Association* and *Grand Central Belge* became so serious that it actually led to the divergence of export channels. While the exact pretext for the escalation of the situation is unknown, it appears that the railway company had resolutely rejected the *Association's* demands for the reduction of transport tariffs. Reacting to this, the *Association's* President Lambert encouraged members to take away from *Grand Central Belge* all transport orders that they possibly could. As a first step in this direction, Jonet (one of the prominent members) mentioned his negotiations with Deferumont, Regnien and Wayland (possibly, merchants or trade agents) to redirect their purchases of glass for London though Ghent (instead of Antwerp). In order to redirect exports though the port of Ghent, the Association wished to reinforce the steamship connection between Ghent and London. Moreover, the President proposed drawing up a petition to the Government in order to 'buy back' this private railway company.[763] Somewhat later the same year, the President emphasised again that the redirection of exports through Ghent and Terneuzen was the best way to 'fight' *Grand Central Belge*.[764] In 1893, the question remained unresolved, as the President mentioned that *Grand Central Belge* still did not wish to lower its tariffs. Therefore, the President encouraged the members to avoid the railway lines of this company as much as possible.[765] The conflict and related negotiations around tariffs for the transport of glass between the *Association* and *Grand Central Belge* dragged on for some time, involving the government as well. At first, these negotiations resulted in the lowering of tariffs by the State Railways, but not by *Grand Central Belge.*[766] This resulted in an unequal situation whereby factories served (having a physical connection) by the State Railways had to pay less for the transport of glass than those served by *Grand Central Belge*. To assure 'fairness', a kind of arrangement was proposed whereby the former group would pay for a special fund, managed by the Association, to compensate the latter group.[767] Yet, a month later, *Grand Central Belge* finally agreed to lower its tariffs.[768]

Questions on railway tariffs were recorded on a few occasions later as well. For instance, in 1899 the *Association* together with the similar organisations of metallurgy and coal mining industries demanded the lowering of tariffs for the transport of coal.[769]

Transport security

Ensuring the safety and security of transport was another semi-permanent concern of the *Association*. While the aforementioned complaints about the railway service do not provide

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[762] Private archive Gobbe, Association, Originaux C, Séance 9 janvier 1878, Séance 11 février 1878
[763] Private archive Gobbe, Association, Originaux C, Assemblée Générale 24 mars 1891
[764] Private archive Gobbe, Association, Originaux C, Assemblée Générale 13 août 1891
[765] Private archive Gobbe, Association, Originaux C, Assemblée Générale 11 août 1893
[766] Private archive Gobbe, Association, Originaux C, Assemblée Générale 15 mars 1895, Assemblée Générale 22 mars 1895
[767] Private archive Gobbe, Association, Originaux C, Assemblée Générale 12 août 1895
[768] Private archive Gobbe, Association, Originaux C, Assemblée Générale 10 mai 1895
[769] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 6 mars 1899

any details in most cases, one specific case from 1867 indicates the frequent problems with cargo safety. The case concerned two crates of glass that were sent by Gobbe from the station of Lodelinsart by *Grand Central Belge*, and appeared to be broken upon arrival in Antwerp. The Commercial Court (*Tribunal de commerce*) of Antwerp had sentenced *Grand Central Belge* to pay Gobbe a due compensation. This was not the first case of its kind, as many members had suffered the same fate on multiple occasions previously. In all the previous cases, *Grand Central Belge* had paid due compensation, yet on this particular occasion it decided to go into cassation for some reason. The *Association* regarded this as an important instance, deciding to support Gobbe by forming a special commission for the detailed study of the case, consisting of Houtard-Rouiller, Francart & de Dorlodot. Moreover, the *Association* decided to seek advice from the lawyer Desquesne in Brussels.[770] Apart from some insights into the transport conditions (apparently, breakage of glass during transport was regarded as more or less unavoidable, and accepted as long as compensation was provided by the railway company), this case illustrates that the *Association* was willing to provide legal support to its members.

A kind of arrangement related to the breakage of glass had ultimately been reached between the *Association* and the *Grand Central Belge* in 1868. While no details on this arrangement are known, it remained effective for years, and speaking as late as in 1880, the *Association*'s President advised all members to join this so-called *convention spéciale relative à la casse* ('special convention related to breakage').[771] It can be assumed that as the breakage of glass had, most probably, been regarded as unavoidable, a special agreement with the railway company at least allowed for issues to be settled amicably, as almost no court cases appeared after 1868.

An exception to this occurred in 1881. One of the *Association's* members, Faginart, found himself in a conflict with the State Railways when the railways refused to compensate him for glass that appeared to be broken upon arrival in Antwerp. As the *Association* considered this case of common interest for all its members, and as it wished to establish the responsibility of the State Railways for transport security, it decided to finance the costs of Faginart's lawsuit.[772] Unfortunately, the outcome of this case remains unknown. Yet it appears that the State Railway did not exactly take their responsibility seriously, as glass breakage on arrival was a constant nuisance and source of conflict between them and the *Association* for years to come. In fact, it became such an issue that, in 1883, the *Association* decided to send a delegation to Brussels to negotiate with the Minister of Public Works on this problem.[773]

Conclusion: Organisations, Institutions and Governance

The functioning of the district was defined by the complex network of relations and interactions between various institutions, acting at various levels. On the regional level, the role of the *Association* appears to be the most important. Its field of action was very broad, ranging from assistance with the provision of fuel and raw materials and assuring transport security to its members to symbolic representation. Two of its functions were, however,

[770] Private archive Gobbe, Association, Originaux A, Séance 16 décembre 1867
[771] Private archive Gobbe, Association, Originaux C, Séance 5 mai 1880
[772] Private archive Gobbe, Association, Originaux C, Séance 4 août 1880
[773] Private archive Gobbe, Association, Brouillons II, Séance 26 octobre 1883

predominant. First, the *Association* played an important role in the coordination of production and trade, concluding multiple temporary arrangements, known as *chômages, conventions, mutualités*, etc, as well as setting prices. Here, the *Association* behaved as a trust. It also acted as a collective 'human resource management'. Interestingly, these arrangements were contradictory to the liberal principles of free competition, often acknowledged by the *Association* rhetorically. It appears that its liberal attitudes mostly related to the international markets (opposition of protectionism), while cooperation between firms within Belgium was tolerated much more.

Yet, some fundamental contradictions appeared. While the need for closer cooperation was often expressed, especially in the late 19th-early 20th century, some 'dissident' members opposed. Most of these 'dissidents' were either located externally (on the periphery of the district like *Mariemont* or even outside like *Binche*), or they were larger firms that were less dependent on cooperation as they had more of their own resources. Hence, the relationship between the collective and individual behaviour of firms in the district is far from a simple dichotomy, as various characteristics of the firms defined whether they would be inclined towards individualistic behaviour or not.

Second, the *Association* engaged very actively in international matters, such as gathering information, establishing contacts with foreign colleagues, international promotion and 'importing' technology (this last aspect will be discussed in the following part). Hereby, the *Association* interacted actively with the national government, including, primarily, the Ministry of Foreign Affairs. The consular network, in particular, proved very useful for establishing international contacts, acquiring information and so forth.

It can therefore be concluded that it was precisely the interaction between institutions on the regional (*Association*) and national (Government, Ministry of Foreign Affairs) level that contributed so much to the success of the district.

Chapter 2.3: Agglomeration effects and external economies

As already discussed in the introductory part, agglomeration effects and external economies are at the core of the industrial districts theory. Originally, the advantages due to the concentration of similar industries (*Marshallian externalities* or *specialisation externalities*) were considered, but later on, advantages due to the interactions between different industries (*Jacobean externalities* or *diversification externalities*) were added to the theory.

This chapter will discuss both types of externalities and their role within the Charleroi industrial district for the window-glass industry.

Jacobean externalities

The Jacobean externalities stem from the interactions between *different* industries. As already discussed in Part 1, Chapter 1.3, the regions of Charleroi and Centre were home to many industries. Although the 'primary' industries, such as coal mining and metallurgy were most important here, other industries, such as various branches of engineering, were present as well. As will be shown in the following section, some of them catered specifically for the needs of the glass industry.

Suppliers of raw materials

The role of coal mining, as well as other primary-material industries (extraction of lime and sand, as well as the chemical production of soda) was already discussed in the chapter on location factors and previously in this chapter, concluding that while it had been one of the decisive factors for the initial location for the industry, its role declined in the second part of the 19th century. While the sources of raw materials were located outside the district (though relatively closely, at least in the case of lime), the district possessed specialised firms that acted as merchants and suppliers of such materials for the local industry.

The *Charleroi-Guide*, a periodical trade directory published as a supplement of the local newspaper *Journal de Charleroi* (1882) mentioned two specialised suppliers. The firm *Depercenaire, Wargny & Ce* in Dampremy supplied the glass industry with limestone as well as (unspecified) chemical products, including sodium sulphate. The firm possessed its own mill for the pulverisation of sulphate. Another firm, Durant-Jennart in Marchienne[-au-Pont] supplied limestone as well as chemical products for the glass industry too. This list should certainly not be taken as exhaustive, as, for instance, the same *Charleroi-Guide* mentioned six glass factories only, while we know that many more existed at the time.
Moreover, the *Charleroi-Guide* mentioned three firms specialised in refractory products (i.e. heat-resistant materials, such as special bricks for furnaces), Victor Baux of Marchienne[-au-Pont] (*briques réfractaires*), G. Houze of Châtelet (*produits céramiques et réfractaires*) and Joseph Gibon of Bouffioulx (*produits céramiques et réfractaires*). Apparently, the firm of Joseph Gibon had already existed for two centuries and had been distinguished at the expositions of Hainaut (1851) and Utrecht (1876).[774] While no specific connection between the glass industry and these firms was mentioned by the *Charleroi-Guide*, it is quite evident that the glass industry needed large quantities of refractory materials, such as refractory bricks for furnaces and annealers. As already mentioned in the chapter on location factors, Bouffioulx and Châtelet were known for their ceramic production.[775]

Some window-glass manufacturers produced refractories for their own use. For example, in 1884, the *Verreries Louis Lambert & Cie* of Jumet-Hamendes applied for a licence to establish a factory for the production of refractory materials needed for their own glass factory. As appears from the description, this new 'factory' should be seen as an extension of the already-existing glass factory rather than an independent establishment. The licence was granted in 1885.[776] This seems to have been an exception, however, as no indication of the production of refractory products by other window-glass manufacturers is to be found in the sources. Therefore, they must have relied on 'external' suppliers.

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[774] *Charleroi-Guide. Indicateur Général, Industriel et Commercial de la Ville et du Bassin de Charleroi. Supplément Hebdomadaire Gratuit du Journal de Charleroi*, N°21 Deuxième année, Dimanche 21 mai 1882
[775] Van Bastelaer, *Les grès wallons*
[776] AvCh, Établissements, JU, BT 114, dossier 3584

Suppliers of general equipment and machinery

The reliance of the window-glass industry on the products of mechanical engineering grew with the introduction of steam engines in the course of the 19th century, and, especially with the introduction of regenerative furnaces from the 1880s on, as they required steam boilers for gas producers (see Part 3, Chapter 3.3). This kind of equipment and machinery (steam engines and boilers) can be described as 'general', as it did not differ significantly from what was used in other industries. In many cases, the owners of window-glass factories acquired these pieces of equipment from manufacturers located within the region itself. This information can be gleaned from the requests for the installation of new industrial equipment and reports on the inspection of steam boilers that are to be found in the municipal archives of Charleroi. Quite often, these requests mention the manufacturer of equipment as well. This data should be seen as indicative rather than quantitative, as not all records had been preserved. The records have only been preserved relatively systematically for one commune, Jumet, with a couple of records for Dampremy and Marchienne-au-Pont. Therefore, the following cases should be regarded as examples. Nevertheless, in my opinion, the number of cases preserved for analysis allows usus to draw some conclusions regarding the interlinkages between the window-glass industry and the engineering industry, albeit without the possibility to make a quantitative analysis.

The following tables provide an overview of engineering firms that supplied equipment to the window-glass factories. Hereby, a distinction between *major* (Table 19) and *other* (Table 20) manufacturers is made. The *major* category includes large engineering firms that were well known internationally and are often mentioned in 'general' literature on the industrial history of Belgium, being, in other words, the 'flagship' enterprises of the Belgian engineering industry. The *other* category includes less important firms that are generally (if ever) mentioned in specialised studies only.

Table 19: Suppliers of industrial equipment for the Belgian window-glass factories (major engineering firms)

Location	Name	Supplies
Couillet	S.A. de Marcinelle & Couillet	Steam boilers for Verreries de l'Étoile (1887)[777] Steam boilers for Verreries d'Ancre (1897)[778]
Brussels	Ateliers Bollinckx	Two steam engines for Bennert & Bivort (1901)[779] Steam engine for Verreries Belges (1901)[780] Steam engine for Verreries de Jumet (1904)[781]

[777] Municipal archives of Charleroi (further: AvCh), Établissements classés (further: Établissements), Marchienne-au-Pont (MAP), BT 10, dossier nr. 247
[778] AvCh, Établissements, Dampremy (DA), BT 2, dossier nr. 58 Verreries d'Ancre
[779] AvCh, Établissements, Jumet (JU), BT 47, dossier nr. 1269, S.A. Verreries Bennert & Bivort
[780] AvCh, Établissements, JU, BT 47, dossier nr. 1270, S.A. Verreries Belges
[781] AvCh, Établissements, JU, BT 47, dossier nr. 1263, S.A. Verreries de Jumet (Verreries Nationales)

Ghent	Ateliers Carels	Steam engine for Verreries Louis Lambert et Cie (1900)[782]
Willebroek (Antwerp province)	De Naeyer	Steam boiler for Verreries Louis Lambert et Cie (1888)[783] Steam boiler for Verreries Louis Lambert et Cie (1891)[784]

Source: Municipal archives of Charleroi, Établissements classés

Table 20: Suppliers of industrial equipment for the Belgian window-glass factories (other engineering firms)

Location	**Name**	**Supplies**
Jumet	S. A. des Usines de Jumet	Three steam boilers for Bennert & Bivort (1900-1901)[785] Steam boiler for Louis Lambert et Cie (1900)[786] Steam boiler for Verreries de Jumet (1901)[787] and others
Couillet	Matissen	Steam boiler for Verreries Louis Lambert et Cie (1887)[788] Steam boiler for Verreries de Jumet (1888)[789] Steam boiler for Verreries d'Ancre (1897)[790]
Montigny-sur-Sambre	Debatty	Steam boiler for Verreries Nationales (1877)[791] Two steam boilers for Eugène Baudoux (1890)[792]
Forchies-la-Marche (near Châtelet)	Fumière Frères Constructions	Two steam boilers for Verreries de la Marine (1906)[793]

[782] AvCh, Établissements, JU, BT 226, dossier nr. 7307
[783] AvCh, Établissements, JU, BT 114, dossier nr. 3584
[784] AvCh, Établissements, JU, BT 117, dossier nr. 3730
[785] AvCh, Établissements, JU, BT 226, dossier nr. 7302, S.A. Verreries Bennert & Bivort; JU, BT 47, dossier nr. 1265 S.A. Verreries Bennert & Bivort
[786] AvCh, Établissements, JU, BT 226, dossier nr. 7307
[787] AvCh, Établissements, JU, BT 47, dossier nr. 1270, S.A. Verreries Belges
[788] AvCh, Établissements, JU, BT 110, dossier nr. 3383
[789] AvCh, Établissements, JU, BT 110, dossier nr. 3375
[790] AvCh, Établissements, DA, BT 2, dossier nr. 58 Verreries d'Ancre
[791] AvCh, Établissements, JU, BT 228, dossier nr. 7344
[792] AvCh, Établissements, JU, BT 118, dossier nr. 3736
[793] AvCh, Établissements, JU, BT 40, dossier nr. 1061, S.A. Verreries de la Marine

Châtelet	S. A. des Chaudières de la Châtelet	Steam boiler for Verreries de l'Étoile (1905)[794]
Montigny-sur-Sambre	J. Jacques	Steam boiler for Verreries Jules Frison (1870)[795]
Charleroi	J. Baily	Steam engine for Verreries Jules Frison (1870)[796]
Lodelinsart	A. Loibotte et Cie	Steam boiler for Verreries Jules Frison (1874)[797]
Bouffioulx	Ateliers de la Biesme	Steam boiler for Verreries Bennert & Bivort (1893)
Clabecq	Hoyois	Steam engine for Verreries Belges (1901)[798]
Gilly	Michel Genard	Steam engine for Verreries Lambert & Cie (1887)[799]
Marcinelle	Auguste Desombay	Steam boiler for Verreries Nationales (1880)[800]
Nimy, Hainaut province near Mons	Mauroy et Lebrun	Steam boiler for Verreries Nationales (1877)[801]
Chênet, Liège province	Mathot et Bailly	Steam boiler for Verreries d'Ancre (1898)[802]
Grâce-Berleur, Liège province	Ateliers Renson	Steam boiler for Verreries Baudoux (1888)[803]
Sint-Truiden, Limburg province	Denuite	Steam engine for Verreries Baudoux (1888)[804]

Source: Municipal archives of Charleroi, Établissements classés

Second-hand equipment

While the aforementioned cases concerned new equipment (steam boilers and machines), the use of second-hand equipment occurred as well. For example, in 1886, a steam boiler originally used by the *Forges et laminoires de Marcienne-Zône* was installed at the *Verreries Schmidt-Devillez* (*la Planche*) in Dampremy, according to the boiler inspection report. The original manufacturer of the boiler was not mentioned.[805]

[794] AvCh, Établissements, Marchienne-au-Pont (MAP), BT 10, dossier nr. 247
[795] AvCh, Établissements, DA, BT 1, dossier nr. 37 Jules Frison
[796] AvCh, Établissements, DA, BT 1, dossier nr. 37 Jules Frison
[797] AvCh, Établissements, DA, BT 1, dossier nr. 37 Jules Frison
[798] AvCh, Établissements, JU, BT 47, dossier nr. 1268, S.A. Verreries Belges
[799] AvCh, Établissements, JU, BT 110, dossier nr. 3383
[800] AvCh, Établissements, JU, BT 228, dossier nr. 7344
[801] AvCh, Établissements, JU, BT 228, dossier 7344
[802] AvCh, Établissements, DA, BT 2, dossier nr. 58 Verreries d'Ancre
[803] AvCh, Établissements, JU, BT 110, dossier 3379
[804] AvCh, Établissements, JU, BT 110, dossier 3379
[805] AvCh, Établissements, DA, dossier 698 Schmidt-Devillez (la Planche)

All in all, it appears that the window-glass manufacturers located within the Charleroi district had a wide scope of suppliers of 'general' equipment to choose from, within as well as beyond the district. One engineering enterprise that seems to have developed a particularly strong connection with the window-glass industry was the *Société Anonyme des Usines de Jumet* that supplied steam boilers to multiple window-glass factories over the years, even though this firm was not specialised in equipment for the window-glass industry specifically. (According to an advertising leaflet of the *Société Anonyme des Usines de Jumet*, which was inserted in one of the files, the firm was specialised in steam boilers, especially of Cornwall-Galloway type, steel roof structures and other steel constructions as well as various types of industrial equipment such as mine carts and steam- and manual-powered cranes.[806]). The fact that it was situated in Jumet, a commune where many window-glass factories were located, was possibly of significance here. However, some glass manufacturers preferred to order their equipment elsewhere in Belgium, for example from *Bollinckx* in Brussels (steam engines) and *De Nayaer* in Willebroek (steam boilers). The choice to use these firms could have been motivated by their special reputation. *Ateliers Bollinckx* was particularly specialised in the production of steam machines for the production of electricity (driving of electricity generators).[807] Not surprisingly, the use of these engines for the driving of electricity generators is mentioned explicitly in the requests by window-glass factories, as was the case for *Verreries de Jumet* in 1904.[808] *Ateliers Bollinckx* had a good international reputation and was an important player on the European market.[809] The firm *De Naeyer* (often spelled as *De Nayer* in texts not written in Dutch) in Willebroek (19th-century orthography: Willebroeck, also often spelled as Willebrouck in French), being a paper mill originally (1860), started to produce steam boilers from 1876 on.[810] De Naeyer steam boilers acquired a good international reputation, and when presented by the firm at the *Internationale elektrische Ausstellung Wien* in 1883 were praised by the *Zeitschrift des Oesterreichisches Ingenieur- und Architekten-Vereins*.[811]

As mentioned above, this data should not be interpreted as entirely representative, nor is it possible to define a percentage of equipment ordered within vs outside the region. At any rate, it can be concluded that while the presence of an engineering industry within the Charleroi region could certainly provide an advantage for the window-glass industry, this advantage was not exclusive nor decisive. Manufacturers located in other parts of Belgium could supply the necessary equipment just as well. After all, the distances were minimal within Belgium, and buying a steam machine or a boiler was not a daily purchase, so the contacts with suppliers could just as easily be arranged outside the district. Hence, while the

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[806] AvCh, Établissements, JU, BT 47, dossier nr. 1292

[807] MOT [Museum voor oudere technieken – Museum of old technologies, Grimbergen], online database. Advertisement "Société anonyme des Ateliers de Construction H. Bollinckx". [digitized copy, undated, early 20th century]. Accessed 09 September 2022. https://www.mot.be/resource/RCB/26310?lang=nl

[808] AvCh, Établissements, JU, BT47, dossier nr. 1263, S.A. Verreries de Jumet (Verreries Nationales)

[809] Jacques Payen, "La position de la France dans l'industrie européenne des machines à vapeur durant la seconde moitié du XIXe siècle," *History and Technology* 1 no. 2 (1984): 193-194.

[810] Eva De Mulder and Veerle Vansant, "Site De Naeyer in Willebroek. De fabrieksgebouwen vertellen: van oprichting tot herbestemming," *Tijdschrift voor industriële cultuur* 27 no. 111 (3d trimester 2010): 3-7.

[811] *Zeitschrift des Oesterreichisches Ingenieur- und Architekten-Vereins*, XXXVI, 1884, p. 75-76 [Dutch translation consulted online, Industrieel erfgoed in Vlaanderen. "De stoomketels van de Elektriciteitstentoonstelling van Wenen." Accessed on 12.09.2022 via http://www.industrieelerfgoed.be/stories/De-Naeyer-ketels-elektriciteitstentoonstelling-Wenen-1883]

presence of a well-developed engineering industry in Belgium can certainly be regarded as an advantage, this advantage was confined to the specific industrial region. Being located in Belgium was more important than being located in the specific region is this respect, making any regional agglomeration effect less relevant in this case.

The same applies, mutatis mutandis, for the market of second-hand equipment. The fact that Belgium possessed a well-developed industrial sector made it possible to acquire second-hand equipment from firms within as well as outside the region.

Suppliers of specialised equipment and machinery

Alongside multiple firms that produced 'general' equipment and machinery which could be employed by various industries, such as steam machines and boilers, suppliers of specialised equipment for the glass industry emerged within the region as well. In fact, according to the literature, a (non-specified) weaponry in Charleroi had switched from the production of rifles to the production of glassblowers' canes already in the early 18th century.[812] Another example is provided by the *Bulletin du musée de l'industrie* (1866). Discussing the Biévez annealers (see Part 3, Chapter 3.3 for technical details), it mentioned that these devices were produced by the Nicaise workshops in La Louvière (Centre, ca. 30 km from Charleroi).[813] Without doubt, this refers to the *Société Parmentier, Nicaise & Cie*, and engineering firm founded in La Louvière in 1855 and specialised in the production of railway equipment and rolling stock primarily. In fact, the production of railway rolling stock was one of the main specialisations of the entire Centre region.[814] This example shows how even the originally unrelated industry could cater for the needs of the glass industry, undoubtedly stimulated by the large demand. While the Centre region is generally considered distinct from that of Charleroi (see chapter on Charleroi and Centre), both industrial districts presented an overlap to a degree, as one literally passed into another. Moreover, the Centre region possessed its own window-glass industry as well. Hence, this instance can be regarded as an example of a technological externality as well.

The aforementioned *Charleroi-Guide* (1882) notes the firm of Alexandre Jacqmain of Lodelinsart-Dechassis as specialised in equipment for glass factories (*matériel de verreries*). The firm possessed its own storehouses and production workshop and supplied canes as well as some other equipment.[815] A later trade directory, *Guide industriel du Pays de Charleroi, Basse-Sambre et Borinage* (1911), featured an advertisement of a firm called *Atelier de construction de Houbois Désiré Wéry* of Jumet. The firm produced a whole range of equipment and machinery for various industries, such as mine carts, ventilation and lifting equipment (undoubtedly for collieries), Wilson and Siemens gas producers, boilers and so forth. Alongside these, the advertisement explicitly mentioned 'devices for window- and plate-glass factories' (*appareils pour verreries et glaceries)*, albeit without further details.[816]

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[812] Bruwier, "De nijverheid voor de industriële revolutie," 18.
[813] "Four à refroidir le verre," *Bulletin du musée de l'industrie*: 50 (1866): 35-36 & 54 (1870): 18-20.
[814] Alain Dewier, "Étude: Approche de la construction ferroviaire dans la région du Centre, des origines à 1985,"*Bulletin trimestriel de l'A.S.B.L. patrimoine industriel Wallonie-Bruxelles,* no. 67-68 (octobre 2006 – mars 2007): 3-5.
[815] *Charleroi-Guide*
[816] Hallet, *Guide industriel du Pays de Charleroi, Basse-Sambre et Borinage,* 178.

It should be noted that the Wilson gas producers were used by the window-glass industry broadly as well (see Part 3, Chapter 3.3). This example illustrates how the linkages between very different industries, such as mechanical engineering, coal mining and window glass developed within the district of Charleroi, as defined in Part 1, Chapter 1.3.

While the firm of Désiré Wéry worked for various industries, some specialised even further, working for the window-glass industry exclusively. One particularly important example was the firm *Gobbe & Pagnoul* of Jumet, which supplied patented tank furnaces of its own design not only to the factories in Belgium, but also abroad, in particular to the United States.[817] The particular history of this firm will be touched upon in Part 3, Chapter 3.3.

An advertisement published in 1933 mentions a specialised firm called *Ateliers de construction Jh. Cosse* of Lodelinsart, which produced and supplied various types of equipment for the window-, plate-, and mirror-glass factories (*verreries-glaceries-miroiteries*).[818] This is beyond the chronological limits of this study. However, if we are to believe Chambon, this firm was founded already in 1865 as *Atelier de construction Joseph Cosse –La verrerie complète*.[819]

Marshallian externalities

The Marshallian externalities stem from the interaction between enterprises engaged in the same industry, such as the window-glass industry in the present case. The three main categories of the Marshallian externalities are the input-output transaction, labour market pooling and technological externalities. In the following paragraph, only the input-output transactions will be discussed. The labour market pooling and technological externalities will be discussed in the next part in the context of the production system.

Input-output transactions

The first type of Marshallian externality is the *input-output transaction*, i.e. the division of labour between firms whereby different firms specialise in different steps within the production process. Here, the output of one firm can serve as an input for another in the form of a semi-finished product. Subcontracting can be seen as an example of this kind of externality as well.

Due to the nature of the production process, the possibilities for the division of labour between firms were limited in the window-glass industry. It is difficult to imagine how the main steps of the production process (melting, blowing and annealing) could have been divided between firms (see also the chapter on technology). Nevertheless, a possibility of the *input-output transaction* existed in the niche of glass decoration and other forms of post-processing.

Domed or bended glass (*verre bombé*) had a number of uses, such as showcases, lanterns, and so forth. Glass rooftiles (possibly intended for glasshouses primarily) were often

[817] *La revanche des verriers*, 15 mai 1895
[818] *La revanche des verriers*, 10 avril 1933
[819] Chambon, *Trois siècles de verrerie*, 61.

mentioned as a popular application of *verre bombé*. The process of *bombage* consisted of the cutting of a sheet of glass into the desired dimensions, followed by the reheating in a special reverberatory furnace, whereby the sheet of glass was laid upon a mould of the desired shape.[820] The cutting of glass to custom sizes for special applications, such as glass covers for photos and engravings, round pieces of glass for clocks or lamps and so forth, was a specialty in itself.[821] The decoration of glass by engraving (by sandblasting or acid, see the chapter on properties and qualities of glass) was another specialisation.[822] Last but not least, glass painting can be mentioned in this respect as well, alongside 'enamelled' glass (*verre émaillé*). While it falls outside the scope of the present study, it can still be considered as a post-processing activity, adjacent to the production of window glass.[823]

All of these activities were present within the Charleroi region. The *Fabrication et travail du verre* provides a (presumably) complete list of firms engaged in these activities, alongside glass factories stricto sensu. The following section is based on this list which reflected the situation as it was in 1907, when the *Fabrication et travail du verre* was published. As for *verres bombés* (including glass tiles), *Fabrication et travail du verre* listed ten firms, all but one located in the Charleroi region (six in Jumet, three in Lodelinsart). The only exception was located in Brussels (Anderlecht).[824] The list for the cutting includes seven firms, all within the Charleroi region (four in Jumet, one each in Gilly, Roux and Lodelinsart).[825]

The picture is different for the engraving and other decorations of glass. Out of the 35 firms listed, only six were located in the Charleroi region (two in Lodelinsart, two in Jumet and two in the Charleroi city proper). Other firms were located in Brussels (15), Antwerp (8), Liège (4), Ghent (1) and Binche (1).[826] The location of these firms in large cities (Brussels, Antwerp, Liège and Ghent) can probably be explained by the proximity of clients (architects, building contractors), while Binche possessed its own window-glass industry. The same logic applies for the firms specialised in stained and 'enamelled' glass. Of 28 firms listed, only four were located in the Charleroi region (three in Jumet and one in Lodelinsart). Others were located in Brussels (12), Antwerp (4), Bruges (3), Ghent (2), Liège (one in the city proper and one in Tilff-lez-Liège) and one in Leuven.[827] The (relative) prominence of Bruges (and, to a lesser extent, Ghent) can be connected to the Flemish gothic revival movement, as exemplified by the figure of Jean-Baptiste Bethune, the 'Belgian Pugin', but this is beyond the scope of the present study.

It should be noted that some firms that produced glass engaged in the decoration and post-processing themselves, hence following an integration strategy (see the chapter on the qualities and properties of glass in the following part). In particular, out of 23 window-glass factories that existed in the region of Charleroi in 1907, three were engaged in decoration and post-processing as well. The *Verreries des Hamendes* (aka *Verreries L. Lambert*) in Jumet and *Verreries de la Planche* (aka *Verreries Léon Mondron*) in Lodelinsart were active in 'cold'

[820] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 112, 181-182.
[821] Ibidem, 183-184.
[822] Ibidem, 186-187.
[823] Ibidem, 187-188.
[824] Ibidem. 242-243.
[825] Ibidem. 243-244.
[826] Ibidem. 248-252.
[827] Ibidem. 252-254.

(engraving) as well as 'hot' (enamel) post-processing, while the *Verreries Goffe et fils* was active in 'cold' engraving.[828]

Conclusion Part 2

As for the *first question* (how and by what factors could the industrial district be defined?), the answer changes over time. Originally, the location of fuel was the defining factor (primitive localisation). It caused the emergence of a pool of highly skilled labour within the region. The importance of fuel declined in the second half of the 19th century, yet the industry did not delocalise. This can be attributed to the concentration of labour (community), that started to act as a location factor in its own right (compound localisation). It can therefore be stated that the localised concentration of labour was responsible for the path dependency. This path dependency was in turn dependent on the exclusive skills that the community possessed. This can be confirmed by the fact that the delocalisation of the window-glass industry to export gateways (port of Zeebrugge) or sources of raw materials (Campine) only started when mechanical production was introduced, making old skills irrelevant. These skills will be discussed in the following part.

Considering the role of institutions (the *second question*), it can be stated that he functioning of the district as a business environment was mostly defined by the *Association*, while the role of the national government was very important for the establishment of commercial relationships, as exemplified by the activities of consuls, or efforts towards international promotion. Here, the *Association* collaborated with the government on multiple occasions. It can therefore be concluded that the success of the district was largely due to the cooperation of institutions on two distinct levels: national and regional.

As for the agglomeration effects and externalities (the *third question*), the labour pool appears to have been the most important externality. Other externalities, such as the presence of suppliers of industrial equipment in close proximity, were not defining. In fact, it is possible to divide the agglomeration effects and externalities into three levels.

On the most local level, the labour pool was defining for the limits of the district. This was made clear in the course of discussions on the *Convention* of 1902-1904, whereby it became clear that only those firms that depended on the common pool of labour were truly 'in' the region. Hence, the 'core' region can be defined as a few communes near Charleroi where most factories were located, such as Jumet, Lodelinsart, Dampremy. Various subcontractors, such as glass decoration firms, were located on this level as well. On the mid-level, the (relative) proximity of raw materials was still important. While not within the district, the sources of most raw materials were still close by, only a few dozen kilometres from Charleroi. Moreover, some specialised suppliers (firms) were located in Charleroi itself. On the highest level, the suppliers of industrial equipment can be situated. While some of them were located in the district (or even in the same commune where many window-glass factories were situated, such as the *Société Anonyme des Usines de Jumet*), industrial equipment was acquired by glass manufacturers from firms located in other regions of Belgium as well.

[828] Ibidem. 248-254.

Therefore, externalities observed on this level (such as the benefit of a well-developed engineering industry in Belgium) can no longer be attributed to the industrial district.

Part 3: Knowledge, Innovation and Craftsmanship

Introduction Part 3

The roles of technology and innovation and the knowledge and craftsmanship needed for them are essential for the development and success of industrial districts in many ways. As can be deduced from the Modified adaptive system model by Martin and Sunley, technological innovation can define the evolutionary path of a district. By applying innovations, an industrial district can escape the decline phase and enter a renaissance. The role of technology is also essential for the four-quadrant model of Andrew Popp, Steve Toms and John Wilson. As various technologies require various resources (including human resources), the changes in technologies are, for a large part, responsible for the organisation and structure of a district. Alternatively, according to the Marshallian theory, industrial districts provide an especially fertile environment for the development of innovation (the *industrial atmosphere*). In a way, the development of an industrial district can be perceived as a self-induced process. Industrial districts can develop technologies that help the move to another development stage (a renaissance). Yet, not all industrial districts succeed.

It is worth discussing a distinction between tacit knowledge (know-how, embodied knowledge) and explicit knowledge (know-that, codified knowledge), as these concepts will be mentioned in many contexts in the following chapters. Tacit knowledge refers to the skills and abilities that are acquired through practical 'hands-on' experience and is often difficult to articulate. It is literally embedded in people's bodies and minds. Explicit knowledge is knowledge that can be more easily expressed through language and codified in books and other documents. The distinction was first introduced by Michael Polyani in the 1960s.[829] However, it should be noted that there is no absolute distinction between these two types of knowledge. All knowing originates in the human mind and is therefore embedded or embodied. There are always tacit and explicit parts to any knowledge. The distinction between tacit and explicit knowledge should be understood as a continuum or spectrum rather than as a dichotomy.[830]

The present part addresses the topics of technology, innovation, craftsmanship and knowledge by considering four questions.

The ***first question*** is, how did the knowledge community come into being and develop within the context of a small region? This chapter will explore the relationship between knowledge and geography, taking into account the diffusion and transfer of technology. Metaphorically, this chapter concerns the 'fertile ground' for innovation.

The ***second question*** is how was the knowledge further developed and managed within the district? Which strategies were employed? Did specific knowledge-management strategies emerge? This chapter will focus, primarily, on patenting as a knowledge-management strategy and on patents as a source. Recent works on patenting and other knowledge-

[829] Virkus, "Tacit and Explicit Knowledge"; Howells, "Tacit Knowledge, Innovation and Technology Transfer," 91-106.

[830] Ilkka Virtanen, "In Search for a Theoretically Firmer Epistemological Foundation for the Relationship Between Tacit and Explicit Knowledge," *The Electronic Journal of Knowledge Management* 11, no. 2 (2013): 118-126.

management strategies will be discussed. Why would inventors patent or not in the first place? After this theoretical discussion, a sample of patents related to the window-glass industry in Belgium will be analysed. However, other knowledge-management strategies will also be discussed. Taking the metaphor further, this chapter looks at the 'seeds' of innovation. Moreover, the roles of individual agency and the collective (that is, that of organisations) will be considered, making a distinction between the interests of individuals who possessed knowledge and employed specific strategies to manage it, and the effects of collective choices for certain strategies. More specifically, the role of the *Association* in the management of knowledge and transfer of technology will be explored.

The *third question*, is how were the innovations put into practice? The technological innovations within the window-glass industry will be explained in the context of the general development of technologies during this period. A twofold interpretative framework will be applied.

First, the framework provided by Ron A. Boschma will be used.[831] This framework conceptualises the history of Belgian technological and industrial development as a series of clusters of innovative industries. This framework will help to explain the degree and the manner in which technological development within the window-glass industry was related to the industrial development of the Belgian economy as a whole. Were the successes and failures of the window-glass industry a direct consequence of the general waves of technological innovation, or was the development of this industry more autonomous?

Second, the developments within the window-glass industry will be related to the historiography of the relationship between craftsmanship and innovation, including the works of Maxine Berg, Pat Hudson and Joel Mokyr. This is a pertinent issue, as craftsmanship remained of essential importance for the Belgian window-glass industry, at least throughout the largest part of the period under consideration. However, as will be argued, this does not imply that this industry was 'backward'. This issue will be linked to the long-standing debate on the exact nature of the Industrial Revolution and the way in which this particular industry 'experienced' the process of industrialisation. Hence, in this chapter, the 'shoots' of innovation will be explored.

The *fourth and last question* is how did the product itself change due to the aforementioned developments? In other words, the final chapter of this part will discuss the properties and qualities of glass. If we are to take the metaphor to a logical conclusion, these were the 'fruits' of technological development.

As in Part 2, the *Association* and its proceedings (as sources) play a dual role. On the one hand, the proceedings function as a 'window', providing valuable and often exclusive information on technological development and knowledge management. On the other hand, the *Association* itself was an actor. While these two aspects are not always easy to keep apart, the distinction should, nevertheless, be kept in mind. For instance, the functioning of the patent system (using the *Association*'s proceedings as a window) was only mentioned when the *Association* itself had to intervene (the *Association* as an actor). Therefore, even if

[831] Boschma, "The rise of innovative industries in Belgium"

the account of the functioning of the patenting system, as drawn from the *Association*'s proceedings, is arguably biased to some degree, it remains an important source, as almost no other relevant sources exist. At the same time, these same accounts inform us on the active role of the *Association* where patenting is concerned. As the only organisation specifically engaged in the development of the window-glass industry, the active role of the *Association* in knowledge-management will receive special attention.

Similarly, invention patents are used as sources in two distinct ways.

On the one hand, invention patents are used in the context of knowledge-management, as patenting was one of various strategies for the protection and dissemination of knowledge. In this context, the 'subjects' of patents (the innovations themselves) are of lesser importance. Most attention goes to questions like what kinds of innovation were patented (and what kinds were not) and why. In more general terms and regarded in this way, patents can provide us with valuable information about the functioning of the 'knowledge community' within the given industry. Here, we will consider <u>patents as a source for the history of knowledge-management</u>.

On the other hand, patents are used as a source of knowledge about the development of technology. Despite their potential value from this research perspective, patents should be used with a certain caution, as the relationship between patenting and innovation is not always straightforward. While not all patents were put into practice as a useful innovation, not all inventions were patented.[832] In some cases, the practical implementation of innovations can be corroborated by other sources, such as descriptions and plans (drawings) of factories, found in the files of the requests for the establishment or modification of factories. In this case we will consider <u>patents as a qualitative source for the history of technology</u>.

Invention patents can also be employed for the study of the history of technology in another way, as an indicator of the general trends of innovative activity. Even if many of the patents were not put into practice, the general trends in patenting indicate which aspects of the production process (specific devices or production steps) attracted special attention in specific periods of time. In a way, patents at least reveal what was seen as 'problematic', 'in need of improvement' and induced most of the 'technological creativity', even if the majority of those improvements remained without practical implementation. However, the impression gained from the quantitative analysis of invention patents can be one-sided. General trends in patenting can reveal certain aspects of innovative activity while eclipsing others. Therefore, corroboration by other sources is desirable. In this case, we will consider <u>patents as a quantitative source for the history of technology</u>.

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[832] Joel Mokyr, "Editor's Introduction: The New Economic History and the Industrial Revolution," in *The British Industrial Revolution. An Economic Perspective*, ed. Joel Mokyr (Boulder, Colorado: Westview Press, 1993), 24; J. Mokyr, *The Lever of Riches*, 247; Moser, Petra. "How do Patents Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs." *The American Economic Review* 95 no. 4 (Sep. 2005): 1214-1216; Petra Moser, "Why don't Inventors Patent?" National Bureau of Economic Research Working Paper No. 13294 (Aug. 2007): 1-2.

Chapter 3.1: The glass-making community and its connections with the larger world

The essential role of community for the development and sharing of technology within the context of industrial districts was exemplified by the metaphor of the 'industrial atmosphere' coined by Alfred Marshall himself. Later research within the tradition of the industrial-districts approach, is epitomised by the 'New Industrial Districts' school. As already noted in the Part 1, this research has emphasised the role of interaction between local knowledge creation within the district (called 'buzz') and knowledge exchange between the district and the outside world (called 'pipelines'). At the same time, other research traditions can also bring important insights. The complex relationship between tacit and codified knowledge is of special interest. It can be directly associated with the relationship between 'modern' technological innovations and 'traditional' manual craftsmanship that typified the window-glass industry throughout the period under consideration.

In order to fully understand how the knowledge 'functioned', it is necessary to consider two points. First, there is the role of uncodified (tacit) knowledge and the significance of human mobility (both individual mobility and group migrations) for the spreading of this knowledge. Second, specific communities were needed to provide the required context (or environment) and resources, both material and non-material, for the transmission and development of techniques. To put it metaphorically, a certain technique can only take root when fertile ground is present.[833]

The relationship between knowledge and geography has received attention from geographers and economists since the 1980s, especially within the context of research and development studies. This research attests that geographical proximity still matters in the late 20th and early 21st centuries, although the effects lessens as codified or explicit knowledge gains in relative importance when compared with tacit or implicit knowledge. From the historical perspective, however, the role of localised communities of practice can hardly be overestimated. However, it needs to be noted that the relationship between tacit and codified knowledge should be thought of as a continuum rather than a dichotomy. There is always a certain degree of 'tacitness' within codified knowledge, although the degree of that 'tacitness' varies.[834]

These insights result from historical research on the dissemination of knowledge in the Middle ages, the Early Modern period and the 19th century. If anything, the role of localised communities in the successful introduction of technologies from elsewhere must have been even larger then due to the larger degree of 'tacitness'. The presence of a community that provided an 'infrastructure' of various material and non-material resources (including skills, raw materials and processes) was important, if not essential for the successful transfer and adaptation of knowledge and technology. At the same time, geographic mobility, be it group or individual mobility, was essential for the transmission of knowledge, especially

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[833] Hilaire-Pérez, Liliane, and Catherine Verna. "Dissemination of Technical Knowledge in the Middle Ages and the Early Modern Era. New Approaches and Methodological Issues." *Technology and Culture* 47, no. 3 (July 2006): 536-540.

[834] Jeremy Howells, "Tacit Knowledge, Innovation and Economic Geography." *Urban Studies* 39, nos. 5-6 (2002): 872-873; Howells, Jeremy. "The geography of knowledge: never so close but never so far apart." *Journal of Economic Geography* 12, no. 5 (2012): 1003-1006.

noncodified (tacit) knowledge.[835] In the 20th century long-distance relationships between firms could increasingly be forged with 'temporary' human mobilities (business visits, conferences and so forth) or simply by means of telecommunications. In previous periods 'permanent' or 'semi-permanent' human mobilities (migrations) were of much greater importance for the exchange of knowledge. Despite this difference, the important role of long-distance exchange of knowledge is emphasised in both approaches. It is only the exact mechanisms of these exchanges that differ depending on the historical context. It is, therefore, useful to investigate how the glass-industry community came into being in present-day Belgium. The industrial district of Charleroi is home to a significant concentration of this community.

As already noted in the historical overview in the Part 1, Chapters 1.4 and 1.5, window-glass production became firmly established in the region of Charleroi by the 17th century, although other types of glass production certainly existed there from at least the 15th-16th centuries on. Interestingly, many 'glass masters' of the period were of foreign origin, as was the case for the families Colnet (Italy) and Desandrouin (France). It is not always clear whether they were already active in glass production, elsewhere, before their arrival in present-day Belgium. However, at least some examples testify to early cases of the long-distance dissemination of knowledge of glass production. For instance, Jean de Condé was one of the first *gentilshommes verriers* from a well-known foreign centre of glass production (Lorraine in his case) to establish glass production in present-day Belgium. He founded his glass workshop in Jumet near present-day Charleroi around 1650 (the city of Charleroi was founded in 1666).[836] As already noted, migrant glassblowers from Southern Germany, Alsace, and Lorraine were already active in present-day Belgium in the first half of the 17th century, while in the next century even more glassblowers from Southern Germany and Alsace were recruited for the production of window glass, bringing the 'secret' (in other words, tacit knowledge) of this kind of production with them.[837] This tacit knowledge remained of essential importance until the First World War, as will be discussed further.

The German origin of many glassblowers was evident from their surnames, such as Schmidt, Andris or Hocquemiller. Some of them could rise and become 'glass masters' (i.e. business owners) themselves.[838] Another interesting indication of the German origin of glassblowers and their technical knowledge was to be found in the terminology. For Instance, in Belgium, the annealer was called a 'stracou'. 'Stracou' was a 'typically Belgian' (or Walloon) word, as in France, for instance, the term 'four à étendre' was used. 'Stracou' is said to be a corruption of the German term Streckhaus[839] The Dutch term for annealer, 'strekoven', is similar as well,

[835] Hilaire-Pérez and Verna, "Dissemination of Technical Knowledge," 536-547; Catherine Brice and Delphine Diaz, "Introduction. 'Mobilities, Know-How and innovation in the nineteenth century'," *Revue d'histoire du XIX^{e} siècle* 53, no. 2 (July 2016): 9-18.
[836] Close, *Les Gentilshommes Verriers du Pays de Charleroi*, 23-26; Hasquin, *Une mutation: le "Pays de Charleroi"*, 195-114.
[837] Joost Caen, *The production of stained glass in the County of Flanders and the Duchy of Brabant from the XVth to the XVIIIth centuries: materials and techniques* (Turnhout: Brepols, 2009), 129, 230, 239-240; Hasquin, *Une mutation: le "Pays de Charleroi"*,126; Poty and Delaet, *Charleroi pays verrier. Des origines à nos jours*, 20-42.
[838] See, for instance, the genealogy of the Schmidt and Andris families, Darquennes and Gobbe, *Sur les traces de verriers: la famille Andris(se)*; Darquennes and Gobbe, *Les verriers Schmidt.*
[839] Jean Pesch, *La verrerie à vitres en Belgique* (n. p., n.p., 1949), 12.

although the etymological connection (the direction of loaning) between stracou, Streckhaus and strekoven is not entirely clear.

The ‘glass-making community’ became firmly established in the course of the 15th–18th centuries, created, to a large degree, by professional group and individual migration. It was within this community of both ‘glass masters’ (entrepreneurs) and glassblowers (workers) that technological developments of the 19th century would take place.

Unlike the 18th century, the 19th lacked technology transfer towards Belgium by means of collective immigrations. On the contrary, from the late 19th century on, Belgian glassblowers started to emigrate to various countries, as already mentioned in the Part 1, Chapter 1.4. In particular, the United States attracted many Belgian workers. At first, the ‘American dream’ turned out to become a nightmare for at least some Belgians. The proceedings of the *Association* from the years 1880-1881 mention the repatriation of some Belgian workers who found themselves ‘in a precarious state’. The Belgian consul in New York showed himself willing to assist in their repatriation. This was not a humanitarian action, as the repatriation costs would later be deduced from their wages in Belgium and they were required by the *Association* to sign their employment contracts before departure from New York.[840]

Somewhat later, from the mid-1880s on, this movement became better organised and facilitated by the establishment of close ties between the American (*Knights of Labor*) and Belgian (*Union Verrière*) unions. In general, Belgian workers established themselves around Pittsburgh and, subsequently, Clarksburg (West Virginia), contributing greatly to the development of the American industry.[841]

Another destination for many Belgian glass workers in the late 19th-early 20th centuries, was the Russian Empire. As mentioned earlier, most of them moved to the Donbass region, where Belgian-owned enterprises, such as *Verreries du Donetz, à Santourinowka*, had already been established.[842] Other places in the Russian Empire attracted Belgian glassblowers as well. For example, on 31 July 1903, a certain Jules Arbé, a young, 14-year-old glassblower, born in Montigny-sur-Sambre near Charleroi, received an official document from the Belgian Ministry of Foreign Affairs, that allowed him to depart for Russia, and asked authorities of all countries to provide him with unhindered passage. His final destination was the Kalishchensky glass factory (Калищенский стекольный завод) (in the present-day town of Sosnovy Bor) in the Saint Petersburg Governorate.[843] This enterprise had been established by Russian entrepreneurs from Saint Petersburg in 1894.[844] As is apparent from this example, this enterprise attracted Belgian workers despite lacking connections with Belgian investors.

Apart from the United States and the Russian Empire, countries such as Italy, Spain, Switzerland and even Japan also attracted Belgian glass workers.[845] Although not all

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[840] Private archive Gobbe, Association, Brouillons I, Séance 3 décembre 1880, Séance 1 avril 1881

[841] Poty and Delaet, *Charleroi pays verrier*, 76-78, 108; Knotter, “Trade unions and workplace organization,” 418.

[842] Darquennes and Gobbe, *Les verriers Schmidt,* 61-63.

[843] Archives Musée du Verre, Charleroi, unclassified documents, document Jules Arbé, no archive code

[844] Sosnovoborsky urban municipality official website. “Stekolny zavod.” Accessed 21 March 2022. https://sbor.ru/city/history/stekolzavod

[845]Poty and Delaet, *Charleroi pays verrier*, 108.

individual stories ended in success, it is plausible to assume that the know-how they brought with them was important, if not essential, for the establishment of the glass industry in these countries. It brings the question of technological development within Belgium to a head.

While the 19th-century mass migrations of workers contributed to the 'export' of knowledge and know-how from Belgium, personal journeys of entrepreneurs and engineers contributed to the 'import' of knowledge, technology transfer and development of innovations. One early case is that of Dominique Jonet. In 1839, he was sent to France, Italy, Bavaria, Bohemia and 'the entire Germany' by his half-brother Léopold De Dorlodot in order to visit glass factories and to learn as much as possible about methods and techniques used there. He was especially interested in coloured glass. His 'grand tour' lasted two years. After his return to Belgium, Dominique Jonet founded a new glass factory with Léopold De Dorlodot as a partner. One of the products of this factory was coloured glass. According to Léopold De Dorlodot, Dominique Jonet was the first 'glass master' in Belgium to introduce this kind of production, as he had learnt the 'secret' of coloured glass during his journey.[846] This is somewhat surprising given the fact that present-day Belgium possessed a flourishing stained-glass production in the previous centuries. It seems, however, that, during the 16th to 18th centuries the majority of coloured glass was imported (although some domestic production certainly existed). By the 18th century, shortages of coloured glass in present-day Belgium were noticeable. Moreover, artistic stained glass largely fell out of fashion by the late 18th century.[847]

This example illustrates both the important role of local, embedded knowledge and practice as well as of long-distance interactions for the functioning of an industrial district. In fact, the de Dorlodot 'family clan' encompassed not only three branches of the de Dorlodot family itself, but they were also connected to the Jonet and Baudoux families, who were also active in the glass industry. The whole 'clan' had been active in the glass industry of Charleroi from the late 17th century on.[848]

For the later 19th century, biographies of engineers, Émile Gobbe and André-Marie Oppermann, help to shed additional light on the matter. Both were of foreign origin, but had nevertheless contributed greatly to the development of the glass industry in Belgium. While the technological aspects of their work will be discussed in the chapter on technology, their itineraries and international connections will be discussed here.

The first, Émile Gobbe (1849-1915) was born in Auberchicourt (France) of a Belgian father and French mother. Gobbe graduated as engineer at the École Centrale in Paris, one of the most prestigious French *grandes écoles*. After working at several French glass factories, he had settled in Belgium near Charleroi, first in Lodelinsart in 1889 and, eventually, in Jumet in 1890. Here, he contributed substantially to the development of a melting furnace in collaboration with various Belgian glass industrialists and engineers.[849]

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[846] Autobiographical manuscript by Léopold De Dorlodot, original preserved in the private archives of the De Dorlodot family, reproduced in Belvaux, *La famille (de) Dorlodot,* vol. 1, 288-289.
[847] Caen, *The production of stained glass*, 231-232, 333.
[848] Belvaux, *La famille (de) Dorlodot,* vol. 1, 275-331, 343-371, vol. 2, 629-634.
[849] Emilio Damour, "L'état actuel et les besoins de la verrerie et de la cristallerie en France," *Revue générale des sciences pures et appliquées* 7 (1896): 68-96 and 135-172; Poty and Delaet, *Charleroi pays verrier,* 172-173.

The second and undoubtedly most 'colourful' figure is Martin-André Oppermann (1846-1930). He was born in the then independent Hanover and he studied engineering at the polytechnic school of his native city, where he graduated with the greatest distinction. At the beginning of his career, he had worked as an engineer in the construction of the Bremen-Oldenburg railway and in the maintenance of hydraulic works in Bremen. However, he soon left his native city forever as he could not bear it to be annexed by Prussia which he hated (because, as he put it himself, 'Prussia had murdered the soul of old Germany'). Leaving Hanover, he moved to England, where he started to work for the firm of the Siemens brothers who played a crucial role in the development of regenerative and tank furnaces. This was one of the fields of activity of the renowned Siemens family of inventors and industrialists alongside better known activities within electric engineering. The Siemens family operated on an international scale, in the United Kingdom as well as in Germany.[850] It was within the Siemens firm that Oppermann developed his knowledge of glass technology. In the course of his employment with the firm, he travelled through France and Belgium in order to work on the construction of furnaces at various glass factories. In 1874 or shortly before, he settled in Charleroi as an 'engineer-entrepreneur specialised in Siemens furnaces'.[851] In the course of following decades, he made key contributions to the further improvement of glass melting furnaces in Belgium, in which he collaborated with various Belgian glass manufacturers.[852] He was naturalised as a Belgian citizen in 1886.[853]

In the course of his later career, Oppermann travelled to Bohemia in order to construct a window-glass factory for a Belgian company there, which he managed for five years. Shortly after 1900, he was sent to the United States by the *Association des Maîtres de Verreries*. In 1903, he presented his report on this travel to the *Association*.[854] This must have been one of his last professional accomplishments, as he most probably retired thereafter. He was almost sixty, after all. After the end of his professional career, he dedicated himself to arts and philosophy, making himself into quite a prominent figure within the local cultural life in the early decades of the 20th century.[855] For instance, he composed multiple concertos for violin and piano that were performed publicly in the festivity hall of the Charleroi Stock Exchange and, possibly, other venues. His paintings were also exhibited on multiple occasions. In addition, he was known as a philosopher and a connoisseur of Eastern spirituality, as he had

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[850] On the development of furnaces by Siemens brothers, see: Michael Cable, "The world's first successful regenerative furnace," *Glass technology: European journal of glass science and technology. Part A* 54, no. 3 (2013): 93-99.

[851] *Journal de Charleroi*, 09 février 1874

[852] Vitaly Volkov, "Een bedrijfstak tussen ambacht en industrie. Innovatie, technologie en kennis in de Belgische vensterglasnijverheid 1830-1914," *Tijd-Schrift. Erfgoedpraktijk in Vlaanderen* 10, no. 3 (Dec. 2020): 72-73; Vitaly Volkov, "Innovation and technology in the 19th-century Belgian window-glass industry," in Vol. 2 of *History of Construction Cultures: proceedings of the 7th International Congress on Construction History (7ICCH 2021), 12-16 July, 2021, Lisbon, Portugal* (London: CRC Press, 2021), 652-653.

[853] "Un pionnier de la verrerie: l'ingénieur Oppermann." *Revue belge des industries verrières* 1, no. 1 (1930): 5-6.

[854] *Journal de Charleroi,* 31 août 1903

[855] "Un pionnier de la verrerie"

published a translation of Yoga Sutra with his commentaries.[856] It is not, therefore, surprising that he was sometimes referred to as 'our Leonardo da Vinci'.[857]

Returning to his professional activities, it can be stated without doubt that his legacy was vast. He held multiple patents for inventions related to various aspects of glass technology, ranging from melting furnaces to glass packaging.[858] His achievements were recognised, as he was awarded a Honour Diploma at the 1913 Ghent World Fair and even received the Order of Leopold, the highest Belgian National Order, in 1925.[859] Another testimony to his professional activities can be found in his personal notebook that has been preserved. It includes notes on various aspects of glass technology (from melting furnaces to glass compositions) that refer to various glass factories, not only in Belgium, but also in the United Kingdom (Pilkington) and Germany (Siemens glassworks in Dresden), illustrating the wide range of his international contacts. Interestingly, the notebook is written in three languages, German, English and French.[860]

We do not know exactly why Gobbe and Oppermann decided to settle and develop their professional careers in Belgium. We may assume, however, that they could choose and compare, as both had visited various glass-producing locations in other countries. Possibly, both were attracted by opportunities that the local environment had to offer. At any rate, with hindsight, their choice was a good one. Collaborating with local entrepreneurs and technicians, they could become successful in developing their innovations, which in turn, contributed substantially to the further development and success of the glass-producing region of Charleroi. These two cases provide perfect examples of fruitful interaction between individuals who developed their knowledge abroad (technology transfer by means of personal itineraries) and the local host community, that could provide a pool of various resources (skills, techniques) for the further development of technology.

Last but not least, one important aspect that characterises a professional community is the (formal) professional education of its members. Unfortunately, information is scarce in this respect. As for the labourers (glassblowers), informal learning on the work floor remained the only way to learn the craft until the First World War. Nevertheless, some kind of supplementary professional education (most probably, of a theoretical nature) existed at the multiple Industrial Schools (*écoles industrielles*) of the region from approximately the 1870s on (see more in Part 3, Chapter 3.2).

As for the entrepreneurs and factory directors, the spread of formal engineering education must be situated in the second half of the 19th century, and even more so in the last quarter. If we are to believe a eulogy in memory of Casimir Lambert (1827-1896, or Casimir Lambert-

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[856] Patanjali, *Yoga Sutra. Traduction et quelques commentaires par M.A. Oppermann* n. p., n. p., 1923.
[857] *Gazette de Charleroi* (12 décembre 1908, 29 novembre 1910, 11 novembre 1912, 17 mars 1913, 03 novembre 1930); *Journal de Charleroi* (11 décembre 1908, 07 février 1911, 12 novembre 1923)
[858] For example: State Archives of Belgium-2, depot Joseph Cuvelier (Further: ARA-2), brevets d'invention (further: brevets), brevet nr. 52563 (1880, for melting furnace improvements), nr. 61792 (1883, for glass packaging), nr. 69954 (1885, mechanical blowing of cylinders)
[859] "Un pionnier de la verrerie"; *Journal de Charleroi* (09 février 1874, 29 février 1920); *Gazette de Charleroi* (24 août 1894, 29 février 1920, 28 avril 1924, 16 novembre 1925, 03 novembre 1930)
[860] Documentation centre of the Museum voor Oudere Technieken (Grimbergen, Belgium), Document 08/322 (notebook Oppermann)

fils, to distinguish him from his father Casimir Lambert, 1798-1864), he must have been the first engineer who 'engaged seriously' with the Belgian glass industry, allowing it to leave the 'empirical trail' (*ornière empirique*) that it had been following for innumerable years.[861] Casimir Lambert-fils graduated as an engineer in 1847 from the *École des Mines* in Mons. After working in his father's glass factory first, he established his own factory. Most probably, he was the first glass industrialist in possession of an engineer's degree.[862] At any rate, there are no earlier mentions of certified engineers active in the Belgian window-glass industry. For instance, the biographic literature does not mention any formal engineering education for the most prominent industrialists of the early 19th century. For example, the biography of Léopold de Dorlodot (1805-1870, full name Léopold-Bernard-Jacques de Dorlodot, also known as Léopold de Dorlodot-Moriamé, not to be confused with his son who was also called Léopold) of the aforementioned de Dorlodot-family clan, does not mention any formal higher education. Neither is any formal education mentioned for his half-brother (they had the same mother) and business partner Dominique Jonet (1816-1872).[863] As already mentioned, Dominique Jonet studied the production of glass informally during his *grand tour*.

The first certified engineer only emerged in the next generation of the de Dorlodot-family clan. Dominique Jonet had two nephews, Léon (1837-1898) and Eugène (1841-1912) Baudoux. While Léon had learnt the task of an industrialist informally, starting in his uncle's factory at an age of 13 or 14 years old and becoming a factory director in 1865 without any formal higher education, his brother Eugène studied at the *École des Mines de* Mons, an engineering school focused primarily, yet not exclusively on coal mining (predecessor of the present day polytechnic faculty of Mons university). According to the information provided by Chambon he became a certified engineer in 1863.[864] Eugène assisted his brother in directing the family factory.[865]

Another prominent glass industrialist of the early 19th century, François Houtart (1802-1876, full name François-Emmanuel-Henri Houtart, also known as François Houtart-Cossé), also had no formal education beyond secondary level. His secondary education was impressive though, as he had attended the *Collège Stanislas* in Paris. Nevertheless, he did not receive any engineering education. This did not prevent him from making important contributions to the development of glass technology, not only in window-glass production (this will be discussed further), but also in plate glass production, as he had been active in both branches of the glass industry.[866]

It seems, therefore, that (at least some) owners of glass factories started to acquire engineering degrees in the second half of the 19th century. Moreover, hired engineers who were not business owners themselves, such as the aforementioned Martin-André

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[861] Private archive Gobbe, Association, Originaux C, Assemblée Générale 30 novembre 1896
[862] Jean-Louis Van Belle, *Henri Lambert. Un grand penseur toujours d'actualité* (Braine-le-Château: La Taille d'Aulme, 2010), 34.
[863] Belvaux, *La famille (de) Dorlodot,* Vol. 1, 280-297.
[864] Raymond Chambon, *Quatre maîtres de verreries belges du XIXe siècle. L. de Dorlodot, D. Jonet, L. Baudoux, E. Baudoux* (n. p., n. p., n. d.), 44-45.
[865] Belvaux, *La famille (de) Dorlodot,* Vol. 1, 296.
[866] Jean-François Houtart, *La famille Houtart* (Brussels: Jean-François Houtart, 2018), 242-247.

Oppermann, started to play a noticeable role in innovation from the last quarter of the 19th century, Oppermann established himself in the region of Charleroi as a professional engineer specialised in glass technology around 1874 (see further). It can therefore be concluded that the glass-making community as a whole remained largely reliant on informal knowledge and know-how until the last quarter of the 19th century.

It is important yet difficult to establish the degree to which the collection of people living in the Charleroi region, engaging in the production of glass in various roles, from labourers to factory owners, can be described as a community. Possibly, it is better to speak of 'communities', distinguishing between labourers (primarily, highly skilled glassblowers) and manufacturers or factory owners. The community of glassblowers was defined by their 'property of skill' primarily (see later in this part), as glassblowing was regarded as an exclusive skill. The establishment of strong unions (*Union Verrière* and *Nouveau Union Verrière,* see Part 1, Chapter 1.4) certainly added to the sense of community within this professional group. As for the manufacturers, family ties often mattered, as exemplified by the de Dorlodot-clan discussed above. The *Association* certainly played a role in the sense of community among the manufacturers, as, by the late 19th century, it united almost all manufacturers. Despite the behaviour of some dissidents (See Part 2, Chapter 2.2), the idea of common interest in the face of challenges such as labour movement and foreign competition was present among the *Association*'s members. Moreover, the preference to present itself as the 'glass community' (*collectivité verrière*) at World Fairs is also telling in this respect. The difference between the two communities can be defined by their relationship with knowledge as well. As will be discussed further, the glassblowers' community was mostly concerned with (or even defined by) the tacit knowledge that remained valuable until the early 20th century, while for the manufacturers' community, importance was given to explicit knowledge. In this way, we can even speak of two distinct knowledge-communities.

Concluding this chapter, we can return to the concept of 'buzz' and 'pipelines' in order to make an assessment of knowledge exchange, both within the local community and between the community and the outside world. The 'buzz' that emerges within the local community is, by its very informal nature, hard to deduce from sources. Yet, the close family ties among both workers and entrepreneurs, strengthened by the common (foreign) origin of many of them, suggests that there was a lot of 'buzzing around' among the glassblowers as well as among the glass masters. As for the latter group, the regular meetings of the *Association* from 1848 on certainly offered an opportunity to exchange ideas. Another indication of active and largely informal exchange of information can be deduced from the high number of patents. While patents served to formalise and protect knowledge, the fact that many similar designs, including some quite 'trivial', were registered within the district suggests that 'ideas were in the air'. This question will be explored further in the following chapter.

At the other end of the spectrum, there are many examples of international connections and contacts that can also be mentioned, such as migrations of professional groups as well as personal itineraries. There are many international contacts maintained by the *Association* that can be added, such as the exchange of information on the state of foreign markets and other commercial affairs through Belgian consuls all over the world (see previous chapter). From the late 19th century on, the *Association* started to establish contacts with English, American and German firms in order to gain information on the latest technologies. While these contacts will be discussed in more detail in the following chapter, it can already be noted that they represented true 'pipelines' as defined by Bathelet. They were formal long-distance contacts deliberately established and maintained with firms outside the district in order to gain access to information that is needed for the success of a district, especially concerning technology.

All in all, the community that had already become firmly established within the region in the 18th century (if not earlier) could provide a fertile ground for the development of innovations in the 19th century. It favoured the exchange of information on both the local ('buzz') and the international ('pipelines') levels. Thus, the evolution of technology transmission can be divided into three distinctive phases. In the first phase (18th century and earlier), the primary 'vehicle' was provided by the immigration of skilled workers. In the second phase (early to late 19th century), individual movements of entrepreneurs and engineers, who acted on their own behalf or in association with individual firms, became the main means of technology transmission. Lastly, from the late 19th century and until the end of the period under consideration, the *Association*, which was a formal business-interest organisation, started to play a primary role in fostering the international exchange of information. This evolution can be interpreted as representing the growing importance of codified knowledge in the context of certain aspects of the production process, such as the furnace technology. However, the fact that skilled Belgian glassblowers continued to be sought after in many countries reminds us that tacit knowledge remained essential within the window-glass industry until the early 20th century. The expansion of the geographical range of these contacts is noteworthy as well. Up until the latter half of the 19th century, these remained largely limited to neighbouring countries, such as France and Germany. From the late 19th century on, the range expanded to a global level, stretching from the United States to Japan. Hence, rather than a general shift from tacit to codified knowledge, we observe geographical expansion of both types of knowledge by the late 19th-early 20th centuries.

Chapter 3.2: The development and management of knowledge

Knowledge-management strategies

As shown in the previous chapter, the glass-making community of the Charleroi region engaged in active exchange of information, including (but not limited to) knowledge related to technology, over long distances as well as within the district itself. This is not unique to the glass-making region and community of Charleroi, of course. Throughout history, the role of communities of practice has remained important in the development and transfer of knowledge, mostly through the use of informal channels. Yet, the way this knowledge had been shared, protected and developed – in one word, managed – changed considerably over time. One of the most important developments in this respect during the period under consideration, was the development of patent laws. How did the emergence of formal protection mechanisms, such as invention patents, influence the localised communities of practice? Why were some communities more receptive to this new knowledge-management mechanism than others? Did geographical proximity inhibit the adoption of formal patenting? Did patenting lead to the 'delocalisation of knowledge'? Alternatively, did the development of formal patenting legislation cause the 'relocation' of knowledge from the centre of production (Charleroi) to the centre of administration (Brussels)?

The emergence of modern invention patent laws from the 19th or, in some cases, even the 18th century, has attracted considerable attention in the past few decades from scholars interested in the history of economic and technological development. Initially, in the 1960s, the emphasis was mostly on the contribution of patents to the general rate of technological innovation within the concept of modern economic growth. The results proved to be ambiguous at best. Depending on the context, patenting appears to have acted as either conducive to or hampering for technological innovation. While, on the one hand, patents provide incentives for inventors to innovate (or, at least, are intended to do this), thus improving the rate of inventions, the temporary monopoly they provide can hinder the further diffusion of knowledge.[867]

More recent research has shifted attention towards questions such as why inventors chose to patent or not in the first place, and how patenting functions within the context of various industries. In this vein, alternatives to patenting are studied as well. Nowadays, patenting is seen as one knowledge-management strategy among many, with its advantages and drawbacks. This strain of research has produced remarkable results. For instance, the work of Petra Moser on patenting in the middle and second half of the 19th century has shown, that, at the peak of the Industrial Revolution, patenting was still the exception rather than the rule. For instance, of all innovations that were presented at the famous Great Exhibition of 1851, only 11% (for the United Kingdom) and 15% (for the United States) were patented. Clearly, the number of patents should not be taken as a proxy for the rate of innovative activity, as the majority of innovations still occurred outside of patent systems. Even more remarkable is the finding that the propensity to patent varied dramatically between industries. For example, for the British innovations presented at the Great Exhibition, patenting rate varied from 5% for chemicals to 30% in manufacturing machinery. For the American inventions presented at this exhibition, the rate of patenting varied from 0% for chemicals to 30% in manufacturing machinery. In general, British and American participants presented quite similar propensities to patent across industries. This is quite remarkable given the vast differences in patenting legislation between the two countries. An application for a patent in the United Kingdom was sixty times more expensive than in the United States. As will be discussed later, Belgian patent legislation was quite democratic, thus being closer to the American example in this respect. Moser attributes these differences to the ability to imitate (to copy or to reverse-engineer), which varied dramatically across industries. Obviously, reverse-engineering was quite straightforward in the case of mechanical machinery, but much more difficult for chemical products. Consequently, the need to formally protect a certain invention was less in the latter case. Interestingly, the propensity to patent within the chemical industry increased steadily with the development of analytical chemistry in the course of the 19th century.[868]

Macro-level research, such as that exemplified by Moser, has been supplemented by a fruitful strain of research on patenting and other knowledge-management strategies in

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[867] Mokyr, *The Lever of Riches,* 247.
[868] Moser, "How do Patents Laws Influence Innovation?" 1220-1222; Moser, "Why don't Inventors Patent?" 3, 18-19.

industry-specific and regional case studies, especially in the British context. Examples include the brewing industry, pottery, the development of steam pumping engines and iron blast furnaces. It appears that various specialised industrial regions developed different innovation systems that relied on various knowledge-management strategies. For example, while the Cornish mining industry developed the steam pumping engine within a system of collective invention without any formal patenting, the North Staffordshire potters made more use of invention patents.[869] The Potteries example is an interesting one, as it bears similarities to glass production. Here, as well, various types of knowledge were necessary (among others, knowledge of furnace design and chemical knowledge of components). It appears that Staffordshire potters were less likely to protect chemical knowledge (composition) through formal patenting, relying on secrecy instead. According to Joe Lane, this can indeed be explained by the relative ease of reverse-engineering of various types of innovations. While pottery-kilns were relatively easy to reverse-engineer, it was almost impossible to reverse-engineer the exact composition of pottery material. In these circumstances, keeping the composition secret was a preferred strategy, as patenting would imply disclosure of the key features of the innovation (components and their ratios).[870]

Summarising the results of research on patenting and other mechanisms for knowledge-management, an analytical distinction between various knowledge-management strategies (or mechanisms) can be made. Moreover, these strategies can be arranged on different axes, the most important of which are the formal – informal and the disclosure (sharing of knowledge) – secrecy (protection of knowledge) axes.

The *disclosure* (openness) of knowledge by the means of written (especially, printed) media as opposed to the merely oral communication was first practiced in consistent way by the authors of treatises on mining and metallurgy, that started to appear in the 16th century.[871] Subsequently, the disclosure of technical knowledge by the means of published treatises, pamphlets or press articles was not uncommon in various industries during the industrial revolution. The motives of innovators to freely share their findings could be various, such as building their own reputation as an expert on the subject, enjoying the moral satisfaction for the 'glory of achievement' or altruistic motives of helping the professional community or even society at large. Moreover, the ability to use the information disclosed was also important. For instance, disclosure was harmless when the information disclosed was very hard or even impossible to apply by an outsider lacking the resources needed. This consideration could favour free disclosure within professional communities, thus forming a key ingredient for *collective-invention* arrangements.[872]

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[869] Alessandro Nuvolari and James Sumner, "Inventors, Patents, and Inventive Activities in the English Brewing Industry, 1634-1850," *Business History Review* 87 (Spring 2013): 95-120; Joe Lane, "Secrets for Sale? Innovation and the Nature of Knowledge in an Early Industrial District: The Potteries, 1750-1851," *Enterprise and Society* 20, no. 4 (Dec. 2019): 861-906.; Alessandro Nuvolari, "Collective invention during the British Industrial Revolution: the case of the Cornish pumping engine," *Cambridge Journal of Economics* 28, no. 3 (2004): 347-363; Robert C. Allen, "Collective invention," *Journal of Economic Behavior and Organization* 4 (1983): 1-24.
[870] Lane, "Secrets for Sale?" 38.
[871] Karel Davids, "Craft secrecy in Europe in the early modern period: A comparative view," *Early Science and Medicine* 10, no. 3 Openness and Secrecy in Early Modern Science (2005): 341-348.
[872] Nuvolari and Sumner, "Inventors, Patents, and Inventive Activities," 108-110.

Selective or partial disclosure was a strategy whereby a part of knowledge was publicly revealed (mostly via trade press or pamphlet), while the rest was offered for sale. The revealed part then acted as a 'teaser' that would persuade the potential client to pay to obtain the rest of a trade secret.[873]

Collective invention was a very specific strategy whereby useful knowledge was exchanged freely among firms in a specific industry without any formal protection. Generally, this kind of arrangement emerged within close-knit communities of practice, especially those concentrated within industrial districts, where geographical proximity favoured the development of mutual trust and a sense of community between the actors. *Collective invention* arrangements were characterised by three main features, viz. incremental innovations, the free disclosure of technical information by participants (firms) through open publication and the employment of this common pool of knowledge for the further improvement of technology. Two classic examples of 19th century *collective invention* are the development of the steam pumping engine within the Cornish mining industry and the development of iron blast furnaces in the English Cleveland district. In both cases, innovation proceeded through the accumulation of minor improvements (incremental innovations), while the information was exchanged freely within the community, without formal protection by means of patenting. In Cornwall, technical information was even shared by means of a monthly journal. Collective-invention regimes took root within communities (districts) engaging in a similar type of production where the business culture favoured collective progress over individualistic competition between entrepreneurs within the community (district). While incremental innovations are not exclusive to the collective-invention context (known as 'micro-inventions' in Mokyrian terms, they could be found in literally all types of industry and industrial settings), the free exchange of information was an essential precondition for collective invention. Arguably, other cooperation mechanisms resulting in technological improvement, such as informal knowledge-sharing and 'learning-by-doing' without written communication, can be designated as 'collective invention' too. However, in this study, the term 'collective invention' will be reserved for a specific concept (or model), first introduced by Robert C. Allen in 1983. Tacit or oral knowledge were not a part of this model.[874]

The *invention patents* that were introduced in various countries from the 18th century on, offered formal (legal) protection of an innovation or invention for a limited period of time (temporary monopoly) in exchange for a disclosure, as the description of the innovation had to be deposited at the patent office. Obviously, the exact conditions of patent protection varied substantially between national legal systems before the international harmonisation of intellectual property rights.[875] The history and functioning of patenting systems (in Belgium as well as in an international context) will be elaborated in more detail in the next chapter.

Secrecy is a century-old and quite straightforward strategy to protect one's knowledge. As noted by Karel Davids, craft secrecy has been a relevant issue in the debates in the mediaeval

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[873] Ibidem, 111-113.

[874] Allen, "Collective invention," 1-3; Nuvolari, "Collective invention during the British Industrial Revolution," 355; Mokyr, *The Lever of Riches,* 250-251.

[875] Mokyr, *The Lever of Riches,* 247-250

and early modern history since the 1980s, as it played an important role in the emergence of the concept of intellectual property. The explicit motions of proprietary attitudes towards the crat knowledge can be traced back to the 13^{th} century.[876] Secrecy remained a valued alternative even after the emergence of formal legal protection in the form of invention patents. Interestingly, secrecy and the dissemination of knowledge are not mutually exclusive, as secrets could literally be traded. In England, for instance, some legal cases in this respect date back as far as 1680s and 1690s. 'Trade in secrets' was an established practice in some industries, especially in textiles and chemicals. The advantages of secrecy were obvious, as it did not require disclosure of sensitive information, and could be maintained perpetually. Secrets, however, were hard to keep, as any worker who was aware of it could divulge what they knew, or just migrate to other regions where they could gain profit from their know-how.[877]

The difficult choice between secrecy and formal protection depended on many considerations, including the nature of a given industry, such as the ease of reverse-engineering, or the degree of tacit knowledge that was required to 'make the invention work'. In the late 19th century, chemists and dyers generally preferred secrecy to patenting, while mechanics (inventors of machinery) were in favour of patents. In general, surveys of inventions suggest that most 19th-century inventors still preferred secrecy to patenting.[878]

As is often (if not always) the case with theoretical classifications and schemes, the empirical experience proves that in many cases, borders are not that clear. Disclosure and secrecy in particular often seem to go almost hand-in-hand despite being on the two extremes of the theoretical axis. As noted by Liliane Hilaire-Pérez and Catherine Verna, secrecy seldom meant total refusal to share information. Rather, it allowed those who possessed valuable knowledge to choose the modalities for and the range of dissemination. 'Enlightened industrialists' such as Matthew Boulton, for instance, allowed visitors to their factories, even offered guided tours. Paradoxically, openly displaying some pieces of information allowed the strengthening of control over others.[879]

Last but not the least, the concept of 'market for technologies' should be mentioned, as it can be useful for the analysis of patenting. Taking the American glass industry as a case, Naomi Lamoureux and Kenneth Sokoloff localised such markets geographically by studying the locations of patent registration for this industry. They distinguished two factors (or channels) that defined such 'markets for technologies', namely a) trade journals that provided general information as well as more detailed descriptions of patent specifications and b) the location of patent agents who could act as intermediaries in the sale of technologies. Interestingly, according to their findings, the geography of patenting in the American glass industry differed significantly from the geography of production. The geography of production was local to Pittsburgh and its surroundings. The geography of patenting remained largely concentrated in regions that, by the late 19th century no longer

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[876] Davids, "Craft secrecy in Europe in the early modern period," 341-342.
[877] Nuvolari and Sumner, "Inventors, Patents, and Inventive Activities," 105-108; Mokyr, *The Lever of Riches,* 250.
[878] Moser, "How do Patents Laws Influence Innovation?" 1214-1216, 1220-1221; Moser, "Why don't Inventors Patent?" 1-3, 18-19.
[879] Hilaire-Pérez and Verna, "Dissemination of Technical Knowledge," 540-541.

possessed much glass industry, such as New England. According to Lamoureux and Sokoloff, this paradox can be explained by the presence of strongly embedded 'markets for technologies' in the 'old' regions.[880] It remains to be seen whether true 'markets for technology' emerged in Belgium and, if this was the case, where were they located. Did they emerge in the region of production (Charleroi), or in the centres of administration (primarily Brussels)?

The following paragraphs will address the second research question in Part 3, that is, how was knowledge developed within the district (and the community), and which strategies were employed. Most attention will be directed to patenting. There are various reasons for this. First and foremost, while the formal nature of this strategy accounted for the presence of a large body of primary sources, namely the invention patents themselves, due to their informal nature most of the other strategies, left few traces. However, quite a few indications of the factual functioning of the knowledge-management strategies within the glassmaking community are to be found in the *Association*'s proceedings, that will be discussed further in this chapter. The proceedings will be used as a 'window', allowing information on various knowledge-management strategies to be gleaned. At the same time, the chapter will explore the role of the *Association* as an active collective actor, engaging in the management of knowledge.

Patenting

Patenting before the 19th century

The World Intellectual Property Organisation defines a patent as "an exclusive right granted for invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. To get a patent, technical information about the invention must be disclosed to the public in a patent application."[881]

This basic definition mentions a number of key elements. First, a patent is an exclusive right, that is, a monopoly. Second, it refers to a product or process, or, to put it in other words, a practical technique. A notion of novelty is therefore implied. Lastly, the obligation for disclosure is mentioned. These elements did not emerge simultaneously. While some are fairly recent, others can be traced back for centuries, or even further. Hence, keeping these basic elements in mind as reference points, a brief outline of the history of patenting is useful.

The oldest system of temporary monopolies for innovations known to us emerged in the Greek colony of Sybaris in Southern Italy around 500 BCE. Curiously, these 'patents' were issued for the term of one year for new culinary dishes. The practice of issuing temporary monopolies or privileges for certain techniques was known in Mediaeval Europe at least from the 12th century on. Examples include windmills and textiles. Yet despite earlier precedents, the first truly statutory codified patent system emerged in 15th-century Venice. The first

[880] Naomi R. Lamoreaux and Kenneth L. Sokoloff, "The geography of invention in the American glass industry, 1870-1925," *Journal of Economic History* 60, no. 3 (Sept. 2000): 706-711.
[881] World Intellectual Property Organization. "What is a patent?" Accessed 24 March 2022. https://www.wipo.int/patents/en/

privilege truly resembling a modern patent was issued there in 1421. Many more followed in the following years, especially after 1450. In 1474, a formal regulation statute, known as the *parte veneziana*, came into being. The 'novelty' element, which was not always present in earlier Mediaeval privileges, was implicitly mentioned in the *parte veneziana*. The protection granted by the Venetian law lasted for ten years. Interestingly, this system was most widespread in glassmaking. Moreover, it was to a large degree through the Venetian glassmakers themselves that this system spread to other places in Europe, as migrant Venetian glassblowers strove for the same protection in their new places of work and residence as in their native city. Importantly, this system did not imply disclosure. The important principle of full disclosure of an invention was first introduced by the French king Henry II. The first published description of a patented invention, namely a kind of a range-finder invented by an instrument-maker called Abel Foullon.[882]

The next important step in the development of patenting legislation was undertaken in 16-17th century England. From 1552, the English crown granted monopolies known as 'letters patent' (from the Latin *literae patentes*), regardless of whether the invention concerned was truly new or not. This practice led to multiple abuses, as the holders of these privileges where typically favourites of the crown rather than true inventors. The discontent this caused among various layers of population, especially guilds, ultimately led to the establishment of the Statute of Monopolies in 1623. This legislation established important principles. The privilege would be granted to the 'true and first inventors'. Moreover, inventions had to be new in England. The protection period amounted to 14 years, which represented twice the apprenticeship period of seven years as was the rule in London craft guilds. The Statute of Monopolies remained the most influential piece of patenting legislation until the late 18th century.[883]

In general, the Venetian law of 1474 was the most influential model for the protection of intellectual property during the Early Modern period in Europe, as it served as an example for the legislation in Spain and the Northern Netherlands (and, presumably, other countries as well), alongside the aforementioned cases of England and France. Despite certain differences between various countries, the basic principle of a special concession, that granted to the inventor exclusive monopoly rights by the sovereign or the republic, remained. In all of these cases, the intellectual property legislation was employed as an instrument of mercantilist policy to a greater or lesser degree.[884]

However, despite common origins and several shared principles, the functioning of patent systems varied greatly between countries before the 19th century. Britain and France present, possibly, the greatest contrast in this respect. In Britain, the role of the patent administration remained mostly limited to mere registration. In general, no preliminary investigation regarding novelty was conducted. Every possible dispute regarding the novelty

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[882] Corentin de Favereau de Jeneret, "Faire germer le progrès. Déterminants techniques, sociologiques et culturels d'inventivité brevetée agricole en Belgique (1830-1930)" (Unpublished PhD thesis (doctorat), Université catholique de Louvain, 2011), 21-24; Maximilian Frumkin, "The Origin of Patents," *Journal of Patent Office* 27, no. 3 (March 1945): 143-145.
[883] de Favereau de Jeneret, "Faire germer le progrès," 24-26; Frumkin, "The Origin of Patents," 145.
[884] Carlo Marco Belfanti, "Between mercantilism and market: privileges for invention in early modern Europe," *Journal of Institutional Economics* 2, no. 3 (2006): 324-328.

and validity was left to the law courts. Neither did the state provide any support to inventors. In France, on the other hand, patent applications were subjected to far-reaching scrutiny. From 1699 on, the *Académie des Sciences* was required to examine patent applications, while other institutions and officials, such as *inspecteurs des manufactures*, could be involved as well. Hence, a French patent was much more difficult to obtain. On the other hand, if the patent was granted, a French inventor was much better off. While English inventors had to pay a registration fee, for his French counterpart, the patent registration was free. On top of that, a French inventor could receive financial support from the state for the implementation of his invention. While both systems aimed at promoting innovation, the means to these ends could not have been more different.[885]

As for the Early Modern Southern Netherlands, a mercantilist policy was followed from the early 17th and throughout the 18th centuries. It was focused on the attraction of foreign artisans and the establishment of new industries. This policy was accompanied by a French-inspired system of privileges and monopolies.[886] As for the glass industry specifically, a privilege granted to Gédéon Desandrouin, a *gentilhomme-verrier* originally from France, to establish a glass workshop near Charleroi in 1688 can be mentioned as an example.[887]

Returning to the definition of the World Intellectual Property Organisation, it can be concluded that all key elements of 'modern' patenting were already present in one form or another before the 19th century. Yet the 19th century brought about significant adaptations to patenting legislation, as it moved from being an instrument of royal prerogative (privilege) towards an instrument (or even a 'weapon') of capitalist competition.[888]

Belgian patenting system in an international context

French revolutionary legislation and its influence

Despite earlier developments, the begin of truly modern patenting legislation can be associated with the French patenting law of 1791, due to both its international as well as conceptual influence. This law spread throughout Europe and its underlying principles remained influential throughout the whole of the 19th century (and, arguably, the 20th). The French patenting law of 1791 spread across Europe in the wake of Napoleon's conquests and served as a model – or at least as an 'inspiration' – in some countries beyond.[889]

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[885] Christine MacLeod, "The Paradoxes of Patenting: Invention and Its Diffusion in 18th- and 19th-Century Britain, France, and North America," *Technology and Culture* 32, no. 4 Special Issue: Patents and Invention (Oct. 1991): 888-891.

[886] H. Verhé-Verkein, "De nieuwe nijverheden te Gent in de XVIIe en XVIII eeuw," *Handelingen der Maatschappij voor geschiedenis en oudheidkunde te Gent* 1, no. 1 (1944): 205.

[887] Poty and Delaet, *Charleroi pays verrier*, 32-33.

[888] MacLeod, "The Paradoxes of Patenting," 888.

[889] Gabriel Galvez-Behar, "Controverses et paradoxes dans l'Europe des brevets au XIXe siècle," in *Innovations et transferts de technologie en Europe du Nord-Ouest aux XIXe et XXe siècles*, eds. Jean-François Eck and Pierre Tilly (Brussels: Peter Lang, 2011), 35-51; Gabriel Galvez-Behar, "The Patent System during the French Industrial Revolution: Institutional Change and Economic Effects," *Jahrbuch für Wirtschaftsgeschichte/Economic History Yearbook* 60, no. 1 Patent Law and Innovation in Europe during the Industrial Revolution (2019): 31-56; de Favereau de Jeneret, "Faire germer le progrès," 27-29.

The most important underlying principle of the 1791 law was the *natural right* of the inventor. Contrary to the old system of granted privileges, this principle implied that the government did not create any kind of privilege by its own agency, but merely acted as a protector of the inventors' rights, which were already present by the mere act of invention. However, the principle of *contract between inventor and society* was present as well. As the protection of inventors' rights came with a high cost, the inventor had to disclose his secret and to withdraw his rights completely after a certain period of time. The tension between these two approaches (patenting protection as *inventor's natural right* vs *contract between inventor and society*) would fuel public debate on invention patenting throughout the 19th century, leading to subsequent patent reform or, in some countries, complete abolition of patenting.[890]

A direct consequence of the adaptation of the natural-right approach in the 1791 law, was the complete abolition of any preliminary examination on the part of public authorities, presenting a total contrast with the French practice of the *Ancien régime*. According to the natural-right view, an invention was regarded as the uncontested property of its inventor. It was therefore not for the authorities to decide whether the invention was worth protection by the means of patent or not. Moreover, no distinction was made between French citizens and foreign nationals. There was only one natural right for everyone, after all.[891]

Another key feature of the 1791 law was the distinction between the *brevet d'invention* (for new inventions), *brevet de perfectionnement* (for improvements, mostly issued for the further development of inventions with existing patents), and *brevet d'importation* (for the introduction of foreign inventions into France). The patenting term could amount to five, ten, or 15 years, with respective fees of 300, 800 and 1,500 francs. The costs were high, and prohibitive for many inventors, as the average daily wage for workers amounted to only 1.5 francs at that time.[892]

As present-day Belgium had been annexed by France in 1785, the 1791 law became legally valid here as in any other part of *la République*. The basic principles of this law remained valid after the defeat of Napoleon, as the patenting law of 27 May 1817 for the newly formed United Kingdom of Netherlands was largely indebted to its French predecessor. For instance, the distinction between the *brevet d'invention*, *brevet de perfectionnement*, and *brevet d'importation*, as well as the protection terms of five, ten and 15 years all remained. The absence of any preliminary examination also continued. At the same time, the new law was mostly motivated by the idea of public good, thus moving from the *natural right* approach towards the *contract between inventor and society* approach. This law remained in place after the Belgian revolution and independence of 1830 and until the reform of 1854.[893]

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[890] de Favereau de Jeneret, "Faire germer le progrès," 27-29.
[891] Ibidem, 28.
[892] Galvez-Behar, "The Patent System during the French Industrial Revolution," 35-37.
[893] de Favereau de Jeneret, "Faire germer le progrès," 30-33; Dekeyser, Collette and van der Tempel, "Twee eeuwen Belgische brevetten," 5-6.

Criticisms and reforms of patenting

Invention patenting was always contested. Returning to France, various reform attempts and proposals were presented on multiple occasions in the first half of the 19th century. One issue that often came to the fore, was preliminary examination. Some actors, such as the *Société des arts et des sciences* of Lille even wished to abolish patenting completely, replacing it with a system of awards in order to support inventors.[894]

In 1844, a new patenting law replaced the 1791 law in France. Unlike its predecessor, the 1844 French law did not state its 'philosophical' bases as explicitly. While the basis of *natural right* remained, there was a clear and noticeable shift towards the *contract between inventor and society* approach. On the practical level, a prominent adaptation considered the position of foreigners. While the 1791 act did not theoretically distinguish between the French and foreigners (one natural right for all), in practice, the *brevets d'importation* caused severe criticism. This provision basically allowed people, who were not inventors themselves, to patent foreign inventions in France, literally stealing them from foreign inventors. The 1844 law abolished *brevets d'importation* while authorising foreigners to patent in France under the same conditions as French citizens.[895]

Last but not least, the 1844 law adjusted the patenting fees. While the total cost of patenting for five and ten years increased to five hundred and one thousand francs respectively, new arrangements made it possible to spread payment over the duration of the protection period, effectively lowering the threshold. This was an important move towards the *democratisation of invention*.[896]

Shortly after the French patent reform, Belgium also decided to change its patenting law. Up to that time, the 'Dutch' law of 1817, based on the French law of 1791, was still in place. The main practical objections to the law of 1817 were twofold. Firstly, the maximal length of protection of 15 years was regarded as too short and insufficient to make enough return on investment. Secondly, the patenting fee was seen as too high. There was a further objection to the old law. Where an inventor acquired a foreign patent for an invention that he had already patented in Belgium, he lost his rights in Belgium. Moreover, the rights of foreign inventors were often violated as, just as in the French case, *brevets d'importation* were quite often registered by Belgians who basically stole inventions from foreigners. Hence, the main objectives of the new law amounted to the strengthening of the inventor's position (for example, by extending the length of protection) as well as a movement towards the democratisation of invention (for example, by lowering the patent fees). After lengthy debates, the new law was approved on 24 May 1854 and remained in place until 1984. From a philosophical point of view, the law of 1854 adopted the concept of patent as a *contract between inventor and society*.[897]

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[894] Galvez-Behar, "The Patent System during the French Industrial Revolution," 36-37.
[895] de Favereau de Jeneret, "Faire germer le progrès," 34-36; Galvez-Behar, "The Patent System during the French Industrial Revolution," 37-39.
[896] Galvez-Behar, "The Patent System during the French Industrial Revolution," 39.
[897] de Favereau de Jeneret, "Faire germer le progrès," 39-41.

The question of preliminary examination caused many discussions. While the 1817 law did not require any examination, some other countries, such as the United States and United Kingdom did subject applications to preliminary examination. The opponents of it opposed it on ideological grounds. It was regarded as an obsolete practice of the *Ancien régime*, incompatible with modern liberal ideas, as it was not for the state to decide which inventions were valuable and which were not. From a more practical point of view, it was regarded as an unnecessary burden for the public administration, that would cost too much taxpayers' money. Moreover, it could lead to partiality on the part of civil servants. The proponents of preliminary examination argued that it would help exclude impractical and even 'absurd' inventions, hence increasing the economic efficiency of the entire patenting system. Eventually, the opponents won, as the new law did not require preliminary examination.[898]

Eventually, the law of 1854 caused multiple changes to patenting procedures. The maximum protection period was extended from 15 to 20 years, making it the longest in the world. The system of payment of patenting fees was reorganised, as the initial one-off payment was replaced by progressively increasing yearly fees. The fee amounted to ten francs for the first year, 20 francs for the second, 30 for the third and so forth. This system made patenting more affordable for less affluent inventors.[899] While shifting more to the *contract between inventor and society* approach on a philosophical level,[900] the 1854 law actually strengthened the rights of inventors in a practical sense and made patenting more affordable, thus, also contributing to the *democratisation of invention*.[901] Moreover, the 1854 law required every patent application to contain a detailed description that would suffice to reproduce the invention. Furthermore, a publication was required within three months of granting of a patent.[902]

All in all, the Belgian law of 1854 was similar to the French law of 1844 in many respects. Both laws implied a move away from the *natural right* approach towards the *contract between inventor and society* approach at a philosophical level, while making patenting more accessible.[903] However, the adaptation of patenting laws in the mid-19th century did not end the criticism of patents. In fact, the principal opposition to invention patents can be traced back to early 19th century England. At first, opponents pointed mostly to the practical flaws of the system, such as long, expensive and uncertain procedures. By the mid-century, economic liberalism, as exemplified by the abolition of Corn Laws in 1846, started to gain momentum. The movement for the abolition of patents spread to continental Europe in the second half of the century, as liberal opinion regarded patents as monopolies. The question caused many debates in Prussia and other German states in particular. For instance, in 1863, 31 Prussian chambers of commerce were in favour of the abolition of patents, while only 16 opposed abolition. In the same year, the VIth congress of German economists adopted a resolution in favour of abolition. Finally, in 1868, Bismark proposed abolition. However, this proposal was rejected due to the opposition of the *Verein deutscher Ingenieure* and some other organisations. While abolitionism ultimately failed in Prussia, it succeeded in the

[898] Ibidem, 47-49
[899] Ibidem, 47-51.
[900] Ibidem, 41.
[901] Ibidem, 51.
[902] Ibidem, 52-53.
[903] Ibidem, 58-61 ; Galvez-Behar, "The Patent System during the French Industrial Revolution," 50-56.

Netherlands, where invention patents were abolished by the law of 15th July 1869. Moreover, it should be noted that some countries never adopted any patenting legislation in the 19th century. These included Denmark, Switzerland, Mecklenburg, Turkey and Greece. This contrasts with the position of Belgium as a prominent pro-patent country.[904]

Internationalisation of patenting

The liberal position on invention patents engendered a paradox. While liberals opposed patents as monopolies, a situation whereby some countries possessed patenting legislation while others did not, caused inequality between countries. Entrepreneurs in countries without patent legislation could use others' inventions for free, while those in countries with legislation had to pay for them. This situation hurt the liberal cause even more. As the total abolition of patents in all countries proved impossible, a movement towards internationalisation of patenting started to gain momentum, as it could place inventors and entrepreneurs in different countries on a level playing field.[905]

The first step towards international legislation on patents was taken at an international conference that was organised at the Vienna World Fair of 1873. It did not bear immediate results, as the French delegation was absent in the aftermath of the Franco-Prussian war. Nevertheless, the process was resumed at the Paris World Fair of 1878. This time, the participants could ratify the first international treaty on intellectual property, known as the *Union de Paris*. According to this treaty, every participating country committed itself to granting the same rights to their own citizens as citizens of other participating countries. However, this did not imply that obtaining a patent in one country automatically produced protection in all other countries. An inventor still had to apply for a patent in every country where he wished to protect his invention, but the procedures were made easier. For practical reasons, the convention prescribed the establishment of national registration offices (*dépôts des demandes de brevet*) in order to facilitate the exchange of information.[906]

France assumed a leading role in the further internationalisation of legislation on patenting and other aspects of intellectual property. After the 1878 World Fair, France established contacts with powerful industrialists all over the world in order to organise a new conference. The aim was to further develop the *Union Internationale pour la Protection de la Propriété Industrielle*. This next conference was held in 1880. Finally, in 1883, representatives of 27 countries met again in Paris for the signing of a new treaty, that can be seen as a further development and finalisation of the treaties of 1878 and 1880. However, only nine participants signed the treaty without reservation. These were Belgium, Brazil, Spain, France, Guatemala, Italy, Portugal, El Salvador and Serbia. Interestingly, the Netherlands and Switzerland were among the participants despite not possessing any patenting legislation at that time. They were allowed to sign the treaty 'under reservation' in anticipation of the introduction (re-introduction in the Dutch case) of patenting in the future. All in all, the 1883 treaty of Paris signified an important step towards the international harmonisation of

[904] Galvez-Behar, "Controverses et paradoxes dans l'Europe des brevets," 43-46; de Favereau de Jeneret, "Faire germer le progrès," 62-67.
[905] Galvez-Behar, "Controverses et paradoxes dans l'Europe des brevets," 47-48.
[906] Galvez-Behar, "Controverses et paradoxes dans l'Europe des brevets," 49-50; de Favereau de Jeneret, "Faire germer le progrès," 69-71.

legislation on intellectual property. However, no unified international legislation was adopted, as participating states received a broad freedom of action to develop their own national legislation. On the other hand, this situation made it easier for new member states to join the Convention.[907]

Belgium did not hesitate to join the convention, as it had already been arguing for the international harmonisation of patenting legislation from the 1850s on. It can be assumed that this attitude was informed by the generally strong export orientation of the Belgian economy, as well as the dominant liberal ideology. As stated by M. Demour in his report to the Belgian parliament in 1884 (quoted by de Faverau de Jeneret), the adaptation of the 1883 Paris Convention was regarded as a small yet important first step towards the unification of legislation on intellectual property related to industry (*propriété industrielle*).[908]

Patent agents

Invention patents can be seen as a key part of the 'market for technology' (or the 'market for innovation'), as they facilitated trade in know-how. Patent agents, that is, lawyers specialised in intellectual property, assumed the role of intermediaries assisting the functioning of this market. In various national contexts, their functions could include the provision of legal information for inventors or the for the trade in patent rights. In the latter case, they can be described as 'brokers'.[909]

In Belgium, patent agents were not covered by any kind of special statute. Apparently, the precise job content of a patent agent could be interpreted in a variety of ways during the 19th century. For instance, according to Henri Raclot, a prominent patent agent active in Brussels (as quoted by de Favereau de Jeneret), the role of patent agent should be limited to that of an intermediary between an inventor and the patent administration. This implied that the patent agent should remain neutral and impartial, and hence abstain from any kind of exploitation and commercialisation of inventions for his own profit. However, as stated by Raclot himself, many patent agents engaged in such activities. Raclot disapproved of such practices, regarding them as an abuse of inventors.[910]

Other patent agents followed different principles, however. For instance, A. Wunderlich [no first name was quoted], one of the most active patent agents in the late 19th and early 20th centuries, offered a whole range of services that clearly went beyond the purely intermediary role. Those included 'research of inventions', preparation of drawings and descriptions, research in current and expired patents, technical translations, sales of patents in foreign countries and others. Clearly, the services he provided went beyond legal advice and assistance, encompassing some technical research as well.[911]

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[907] Galvez-Behar, "Controverses et paradoxes dans l'Europe des brevets,"49-51; de Favereau de Jeneret, "Faire germer le progrès," 72-77.
[908] de Favereau de Jeneret, "Faire germer le progrès," 78-79.
[909] Lamoreaux and Sokoloff, "The geography of invention in the American glass industry," 701-703; Galvez-Behar, "Controverses et paradoxes dans l'Europe des brevets," 42; de Favereau de Jeneret, "Faire germer le progrès," 54.
[910] de Favereau de Jeneret, "Faire germer le progrès," 55.
[911] Ibidem, 55-46.

According to a treatise published by another patent agent, Jacques Gevers, active in Antwerp before and after the First World war, the main function of a patent agent was to guarantee the 'novelty character' of an invention, in order to assure successful commercialisation.[912]

Patenting culture

The development of legislation and the practice of patenting, as previously described, was closely related to the technological and economic context. However, in the course of the 19th century, patenting started to play an increasing role in the broader social context and even culture to the degree that it has become possible to speak of patenting culture. Focusing on Belgium, but taking into account the broader European context, Corentin de Favereau de Jeneret has examined the main features of this patenting culture (*culture de brevet*).[913] The patenting culture approach places emphasis on social and cultural factors as determinants of patenting behaviour. This approach can be seen as complementary to the concept of propensity to patent, which is based on economic and technological factors and is exemplified by the aforementioned work of Petra Moser. The propensity to patent approach is most useful for understanding the varying levels of patenting in different industries. The patenting culture approach can surely contribute to our general understanding of the motivation of inventors (across various industries) to apply (or not) for a patent in a specific society and during a specific period.

The patenting culture, as elaborated by de Favereau de Jeneret, focuses mainly on the attitudes towards innovation and innovators (inventors) in Belgium and Western Europe during the 19th century, as well as on the social representation of patents themselves. In general, the perception of innovation was positive among a large part of the population during the 19th century, as it was regarded as a source of well-being, wealth, civilisation and peace, in one word – progress. Patenting contributed to this attitude, as it was seen as conducive to progress in general. The creation of Belgian legislation on patenting was motivated by the desire to stimulate the development of national industry and the well-being of the entire population.[914]

The evolution of the popular image of an inventor in the 19th century can be divided in two stages. The 'mechanic inventor' of the early 19th century was followed by that of the 'scientist inventor' in the later 19th century.[915] This change can be attributed to the changing role of science, or, at least, to a more formalised and theoretical (as opposed to tacit or more practical) approach to technology.

The popular image of an inventor as a 'hero of our time' emerged in England in the early 19th century. The fundraising campaign for the erection of a statue of James Watt in 1824 can be seen as more than symbolic in this respect. Concurrently a true 'national pantheon' of great inventors, such as George Stephenson, Richard Arkwright and Edmund Cartwright came into being. In general, the early 19th century image of an inventor was not unlike that

[912] Ibidem, 57.
[913] Ibidem, 292-303, 324-356, 383-386, 390-480.
[914] Ibidem, 325-327.
[915] Ibidem, 352-354.

of a romantic hero. He (almost never 'she') was regarded as an almost messianic figure, inspired by genius, standing outside (or even above) society, yet working hard and undergoing hardships in order to help this same society to progress. The humble origin of many inventors was often emphasised. Practical experience was regarded as more important than formal education. An 'ideal' inventor of the early 19th century was a creative and perseverant mechanic or even labourer, not a scholar with a university degree. As a true romantic hero, he was often represented as a tragic, yet admirable character, a martyr to progress.[916]

This image changed in the latter part of the 19th century, especially from the 1880s on. The 'messianic' character gradually disappeared. Invention came to be regarded rather as a rational (re)combination of elements rather than an act of genius or 'divine' inspiration. At the same time, as the further development of technology came to be increasingly dependent on science, the inventor mechanic came to be replaced by the inventor scientist. The role of practical experience as opposed to theoretical knowledge diminished. Gradually, the figure of scientist started to replace that of inventor as the herald of progress. Hence, we can speak of 'scientification' of invention in this context.[917]

Nevertheless, the image of inventor remained predominantly positive throughout the 19th century. The same was true for the patent, as it was seen as proof of recognition by society. Invention patents were used in advertising and promotion as quality brands, where they were mentioned alongside exposition prizes.[918]

Paradoxically, this positive image of the invention patent stood quite far from the economic reality. In fact, an absolute majority of all patents issued never provided any benefits to their inventors. The popularity of patenting contrasted sharply with a, generally, very low (most often totally absent) return on investment. For most inventors, their invention was nothing but failure. Invention patents can hardly be seen as quality marks, as they were issued without any preliminary examination.[919]

Yet the number of patents rose sharply despite this, especially after the law of 1854. According to de Favereau de Jeneret, this was a direct consequence of the prevailing culture. Many 'small' inventors became inspired by the examples of 'great inventors', that were prevalent in the culture, but they ultimately failed. Hence the 'invention culture' and 'invention reality' could not have been more different.[920]

Patenting: Summary

Belgium inherited its patenting legislation from revolutionary France (the 1791 law). The French 1791 law was a result of a long historical development, starting with the *parte venziana* (1474) or even the 'culinary patent' of Sybaris (ca. 500 BCE). The 1791 law

[916] Ibidem, 327-337.
[917] Ibidem, 352-354.
[918] Ibidem, 355-356.
[919] Ibidem, 390-391.
[920] Ibidem, 450-457.

incorporated all of the key elements of modern patenting as defined by the World Intellectual Property Organisation.

The underlying philosophy of patenting legislation shifted from the *natural right of inventor* of the French law of 1791 to the *contract between inventor and society* of the Dutch law of 1817 and the subsequent law of 1854 that replaced it. However, from a more pragmatic point of view and from the perspective of both a 19th-century inventor as well as 21st-century researcher, practical rights granted by the law to inventors are more important,. The absence of preliminary examination (laws of 1817 as well 1854) certainly lowered the threshold to patent for would-be innovators, adding to the democratisation of patenting. At the same time, it must have lowered the 'quality' of patents, allowing trivial and even impractical inventions to be patented. This democratisation of invention was taken even further by the law of 1854, due to the long protection term as well as the more affordable system of registration fees.

Belgium was one of the most 'pro-patent' countries of the 19th century. Not only did it grant very favourable conditions to its own inventors, but it also engaged actively in the internationalisation of patenting, being one of original signatories to the *Union de Paris* (1883). Belgium attracted many foreign inventors who wished to apply for a Belgian patent.

The functioning of patenting systems was aided by patent agents who provided various services to inventors and would-be inventors, and played an important role as 'brokers' in the 'market for technologies'.

Last but not least, the positive patenting culture contributed to the popularity of patenting. Yet, the image of inventor changed significantly after the 1880s, a change which can be summarised as the 'scientification' (or at least 'technologisation') of invention.

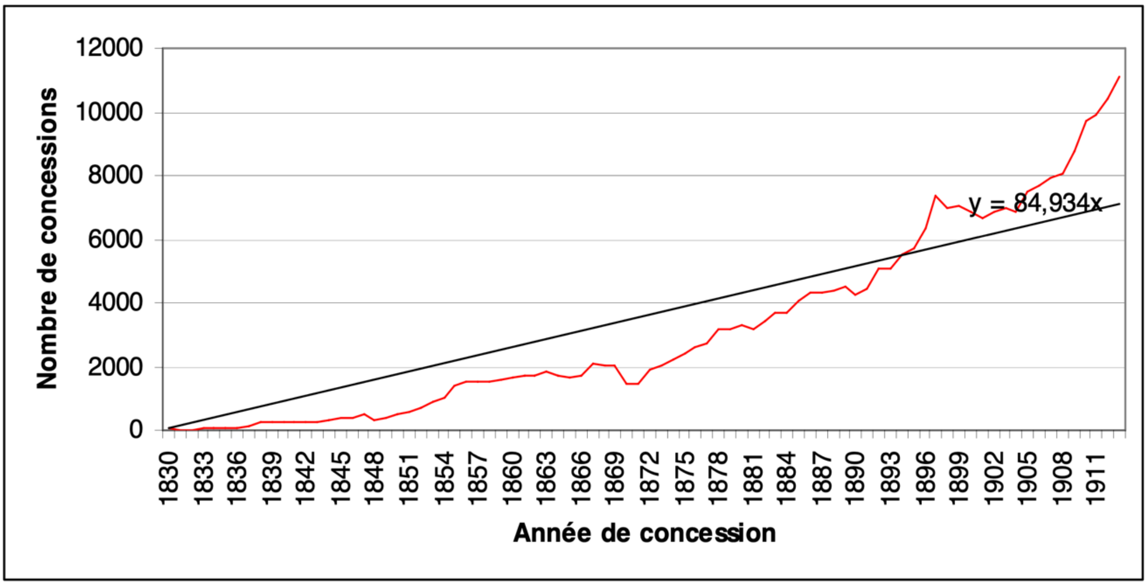
Based on this, the following hypotheses can be formulated for the analysis of invention patents, both quantitative and qualitative. Thanks to the democratisation of patenting and a positive patenting culture, a high propensity to patent (a large number of patents) is to be expected, especially after 1854. At the same time, a large number of 'trivial' (or even impractical) inventions is also to be expected due to the absence of preliminary examination. However, due to the 'scientification' of invention in the late 19th century, a decrease in the number of such patents is also plausible. A large number of foreign patents is also to be expected, especially after the Union de Paris. As for the patenting agents, it is difficult to make an assessment of their importance. The following analyses will also address this question.

The analysis of invention patents

The following paragraphs will focus on patents in order to, partly, address the second research question of Part 3, that is, how was knowledge developed and managed within the district, which knowledge-management strategies were employed (or not) and why. To start with, general trends in patenting activity will be established. After this, the geography of patenting will be analysed, in order to establish to what degree inventive activity was embedded in the district itself (and, hence, rooted within the community). Last but not least, various types of knowledge, related to distinct aspects of window-glass production will be analysed. This analysis will enable identification of the limits of patenting as a knowledge-management strategy. Using Petra Moser's theory as a hypothesis, an explanation for the observed limitations of patenting as a knowledge-management strategy will be proposed. After the presentation of quantitative analysis, a qualitative account of the functioning of the patenting system will be presented, as found in the *Association*'s proceedings. The role of individuals (such as the social position of inventors, as far as it is known from the patents) will also be addressed.

As noted previously, the threshold to patent was low in Belgium as compared to other countries thanks to the long protection period and relatively low fees. Moreover, the Belgian patenting office did not subject patent applications to any expert judgement, nor did it establish whether a similar innovation had already been patented. This made Belgium extremely attractive for foreign patent holders as a kind of 'patent offshore'. In fact, after 1850, the number of 'foreign' patents (both *brevets d'importation* and Belgian patents issued to foreign nationals) exceeded the number of 'Belgian' patents. Between 1830 and 1880, Belgium was the country with the largest number of patents per capita in the world. The sheer number of patents grew substantially during the 19th century. In 1830, only 53 patents were issued, but in 1850, there were 495, and in 1900 there were 6,885.[921]
The Figure 9 illustrates the steady increase in the total number of patents issued in Belgium between 1830 and 1914.

Figure 9: Evolution of the number of patents registered in Belgium, 1830-1913



Source: de Favereau de Jeneret, "Faire germer le progrès, " 122

From 1830 to 1854, patents were published in the *Catalogue des brevets d'invention.* From 1854 on, it was replaced by the *Recueil des brevets d'invention publié en exécution de l'art. 20 de la loi du 24 mai 1854*. The *Recueil* published only a short description of the invention, while the complete dossier can be consulted in the archive. These inventories mention the

[921] Dekeyser, Collette and van der Tempel, "Twee eeuwen Belgische brevetten," 6-7.

name and location (place of residence) of a patentee and a short description of the invention (see Appendix for detail on retrieval of patents).[922]

These official published inventories were used to collect a database for this study. For the first two decades (1830s and 1840s), the entire period was sampled. After 1850 this became impossible due to the rise in the total number of patents. Therefore, from 1850 one year in each five-year period was recorded (1855, 1860, 1865… 1910). Although patent legislation in present-day Belgium goes back to 1795, patent records have only been systematically preserved since 1830, the date of Belgian independence in, at least in the Belgian archives. Therefore, for practical reasons, the period under investigation is defined as 1830-1910. The complete list of all invention patents used in the sample is provided in the appendix. All further graphs are based on the same sample.

As the scope of research concerns blown window glass only, patents related to other branches of the glass industry (including cast plate glass) were excluded. Patents related to 'cold' working (mostly decoration) of glass (engraving, sandblasts, etc.) were also excluded, as these processes were generally conducted by specialist firms and not by glass factories. On the other hand, the equipment for cutting glass is included, as this operation was conducted in all glass factories. The patents related to 'general' innovations that were applicable to various branches of the glass industry, including window glass, were also included.

As an official document, each invention patent file contained a number of standardised parts. First, the title page mentioned all administrative data, such as the name of the patentee (in some cases, his representative as well), the date and the place (geographical location) and a short description of the invention. The title page was followed by a detailed description of the invention, often accompanied by a drawing. As noted above, the law required the description to be detailed enough to reproduce the invention, although, as my research indicates, the level of detail in descriptions varied. While some inventors included entire multiple-page treatises, reflecting on the present state of technology and indicating explicitly in what way their invention would improve a process, the majority preferred to keep it short and simple, providing a concise technical description only and merely an indication that their invention would signify an improvement. Most invention patent files also included detailed drawings. However, drawings are generally lacking in the (not exactly numerous) chemistry-related patents, as well as in some patents related to simple mechanical devices. In such cases, a verbal description was apparently regarded as sufficient.[923]

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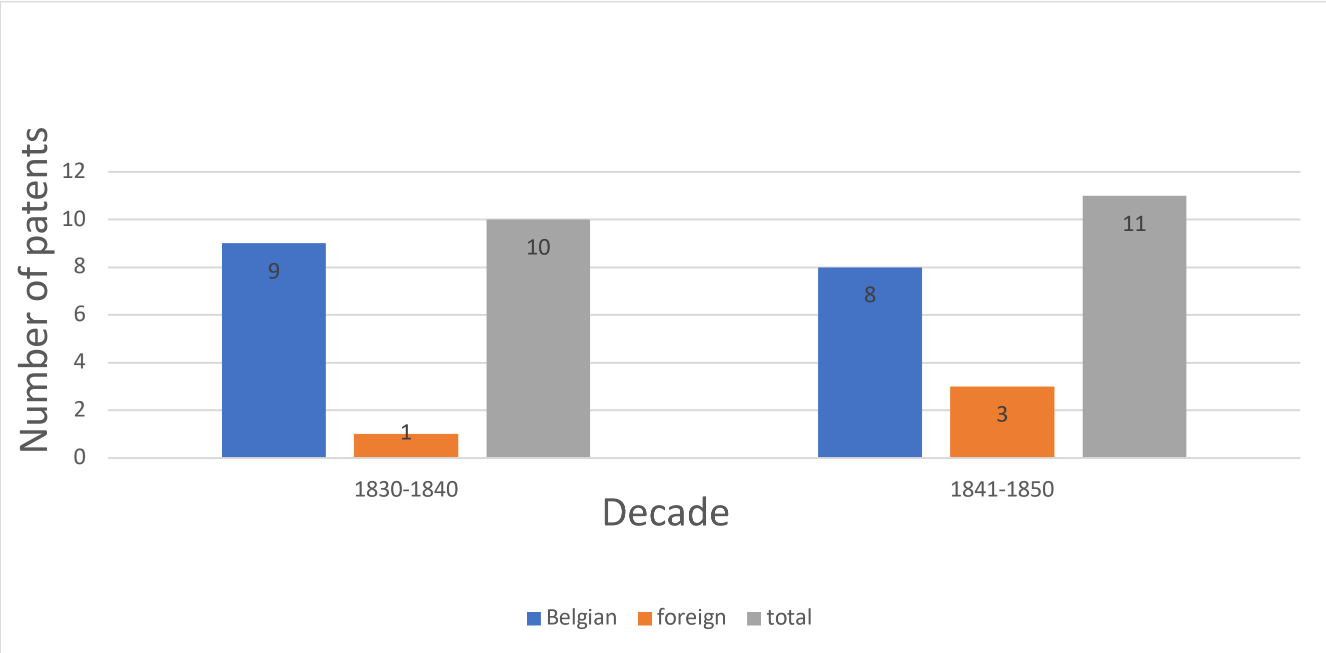
922 Dekeyser, Collette and van der Tempel, "Twee eeuwen Belgische brevetten," 4-16; Paul Servais, "Les brevets d'invention en Belgique de 1854 à 1914," in Vol. 2 of *LI^e Congrès de la Fédération des cercles d'archéologie et d'histoire de Belgique et 4^e Congrès de l'Association des cercles francophones d'histoire et d'archéologie de Belgique. Liège 20-23 VIII. 1992. Actes*, 360-377. (Liège: n. p., 1994), 360-377 ; Michel Oris, "Inventivité technique et naissance d'industrie innovative en Belgique, 1860-1910," In *Technology and Engineering*, eds. M. Lette and M. Oris, 139-162. Vol. VII of *Proceedings of the XX^th International Congress of History of Science, Liège 20-26 July 1997* (Turnhout: Brepols, 2000), 139-162 ; Corentin de Favereau and Arnaud Péters, "Vers une histoire du système belge des brevets au XIX^e siècle," in *Innovations et transferts de technologie en Europe du Nord-Ouest aux XIXe et XXe siècles*, eds by Pierre Tilly and Jean-François Eck, 53-67 (Brussels: Peter Lang, 2011), 53-67.

923 Dekeyser, Collette and van der Tempel, "Twee eeuwen Belgische brevetten," 7-8.

General trends in window-glass patenting

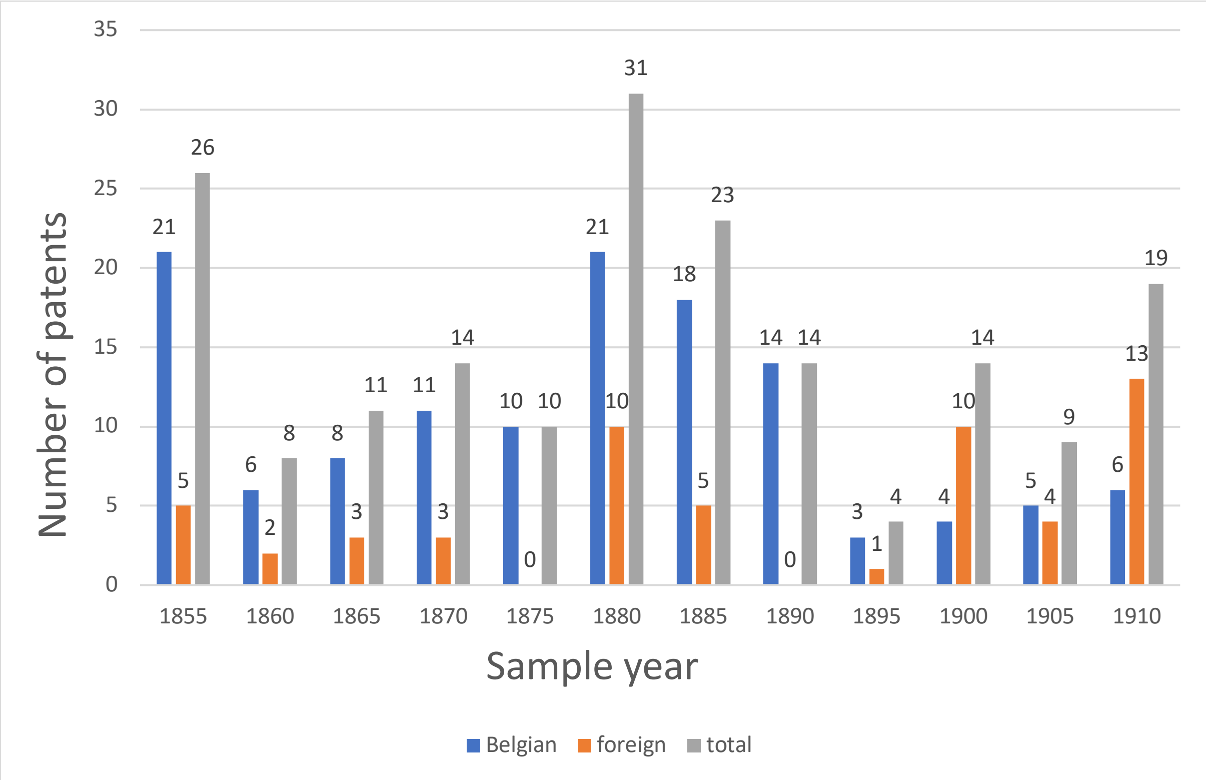
The following diagrams (Graphs 3 and 4) represent general patenting trends in the Belgian window-glass industry from 1830 to 1910. For reasons explained above, these two periods are represented in two separate diagrams – 1830 to 1850 and 1855 to 1910. For the period 1830 to 1850, patents are grouped in two decades (1830-1840 and 1841-1850). For the second period, a sample of one year in every five is provided.

Graph 3: Patenting in the Belgian window-glass industry: General trends in the number of Belgian and foreign patents registered in Belgium, 1830-1850



Source: sample by Vitaly Volkov, see Appendix for the full list

Graph 4: Patenting in the Belgian window-glass industry: General trends in the number of Belgian and foreign patents registered in Belgium, 1855-1910



Source: sample by Vitaly Volkov, see Appendix for the full list

The general trends clearly indicate two waves of inventive activity, the first one between 1830 and approximately 1860, and the second between approximately 1860 and 1895. These waves can be related to the development of annealers for the former and of melting furnaces for the latter. Interestingly, the number of Belgian patents drops sharply after 1890, overtaken by foreign patents. This is especially remarkable given the sharp increase in the number of patents in Belgium in general (graph from de Faverau de Jeneret). Apart from technological developments themselves, which will be discussed later, the sharp increase in the number of patents in 1855 can be attributed to the law of 1854, which lowered thresholds to patent, especially for inventors of modest origin. In the same vein, the increase in the number of foreign patents after 1890 can, at least in part, be attributed to the 1883 Paris Convention for the Protection of Industrial Property. It is nevertheless remarkable that the increase in foreign patents only started to occur after 1900, while it actually declined between 1880 and 1895. Clearly, legislation alone cannot explain the general trend. In the following chapters, more qualitative analysis of the technological innovation will contribute more insights into the relationship between trends in patenting and the development of technology.

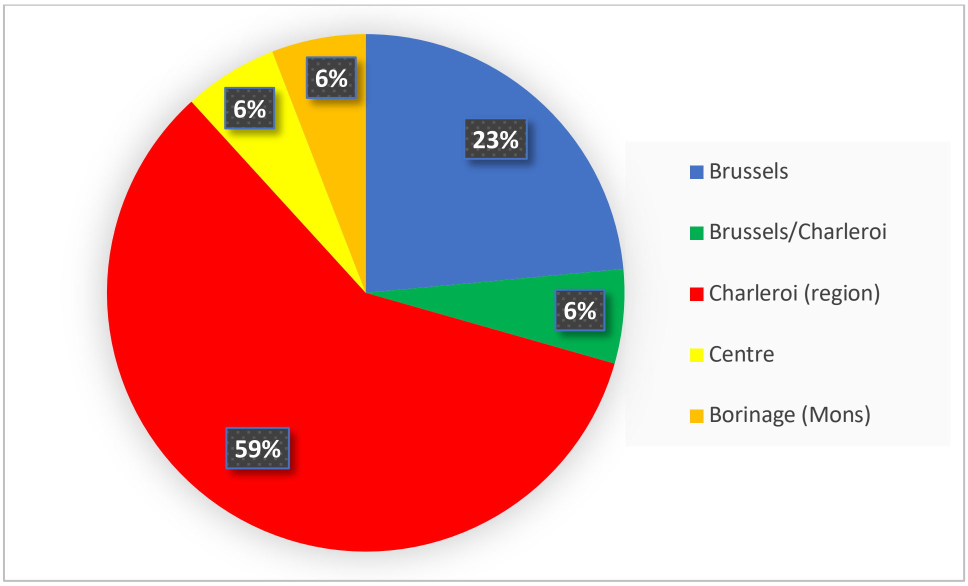
The Geography of window-glass patenting

The 'location' provided in each patent allows us to study the geography of inventive activity. Unfortunately, the 'location' as mentioned in patents is rather ambiguous. According to Paul Servais, the location referred to the place of residence of the inventor.[924] However, according to Corentin de Faverau de Jeneret, the 'location' more often referred to the place of registration of the patent, and not necessarily to the true location of the origin of the patent (place of residence of the inventor). The systematic registration of the place of origin only started to be recorded from 1895-1898 on.[925] As for the place of registration, Liesbeth Dekeyser et al mentioned that patents could be registered at 'local offices', yet no list of such offices is known to us.[926] According to Arnaud Péters the patent registration system was decentralised and organised, primarily, at the level of provinces. Yet again further detail such as the number and location of local patent offices was not provided.[927] Arguably, it can be assumed that such offices existed in larger cities, especially those with significant industrial activity (such as Charleroi), yet it seems unlikely that smaller communes possessed patent registration offices. However, this remains just an educated guess. While these limitations should certainly be kept in mind, the analysis of 'location' as provided in patents is still valuable in my opinion. Even if we do not know for sure whether the 'location' mentioned in every specific patent referred to the place of residence of the patentee or to the location of the local patent office, the data on 'location' is still valuable as it can provide us at least a regional (if not local) distribution of inventive activity.

For analytical purposes, four regions can be distinguished: the Charleroi region (including the Charleroi city proper and the surrounding communes such as Jumet, Lodelinsart, Dampremy Roux, Couillet), the region of the Centre (the cities and communes of La Louvière, Saint-Vaast, Haine-Saint-Pierre), Borinage (the city of Mons and the surrounding communes) and Brussels (within the limits of the present-day Brussels Capital Region), plus some other locations outside the aforementioned regions, such as Namur and Liège. The diagrams (Graphs 5 and 6) represent the geographic distribution of patenting for Belgian patents (foreign patents are not included). The total number of Belgian patents amounts to 17 for the first period (1830-1850, full sample) and 125 for the second period (1855-1910, five-year sample).

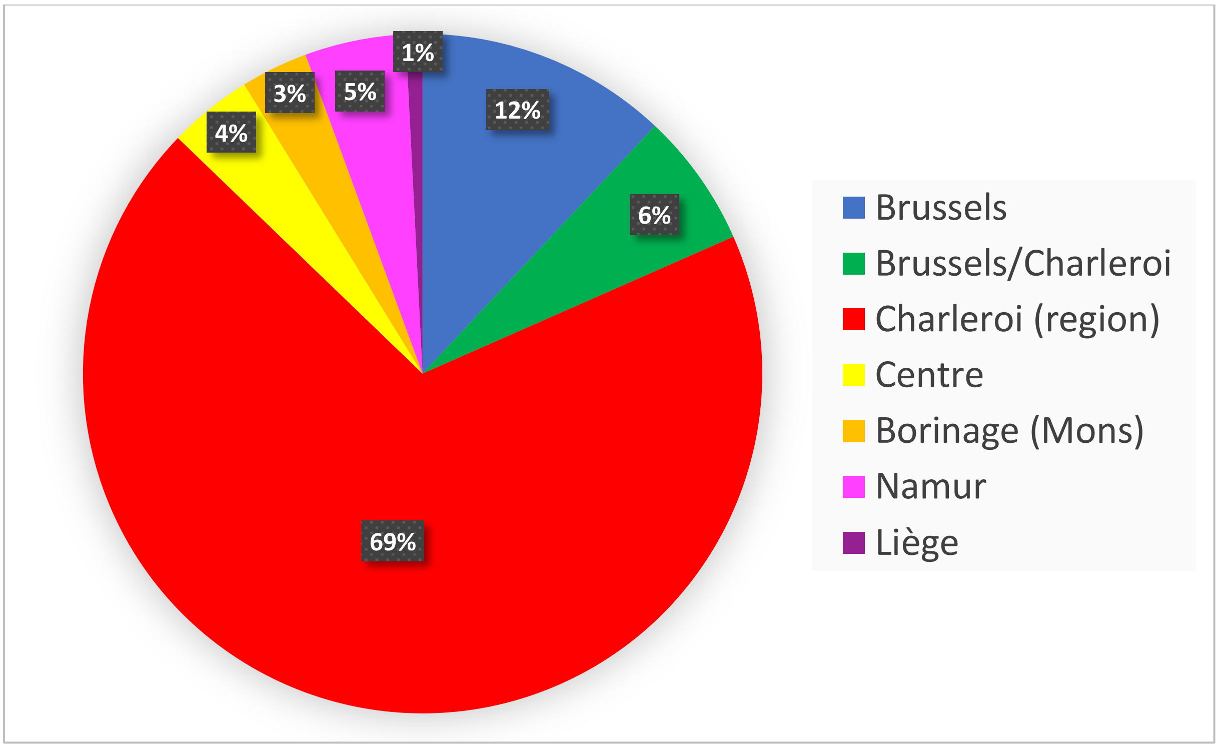
[924] P. Servais, "Les brevets d'invention en Belgique de 1854 à 1914," 366.
[925] de Favereau de Jeneret, "Faire germer le progrès," 89-91.
[926] Dekeyser, Collette and van der Tempel, "Twee eeuwen Belgische brevetten," 7.
[927] Arnaud Péters, "Le système belge des brevets au 19e siècle," Gehec Newsletter (2006)

Graph 5: Patenting in the Belgian window-glass industry: geographical distribution of locations as indicated in patents, 1830-1850 (n=17)



Source: sample by Vitaly Volkov, see Appendix for the full list

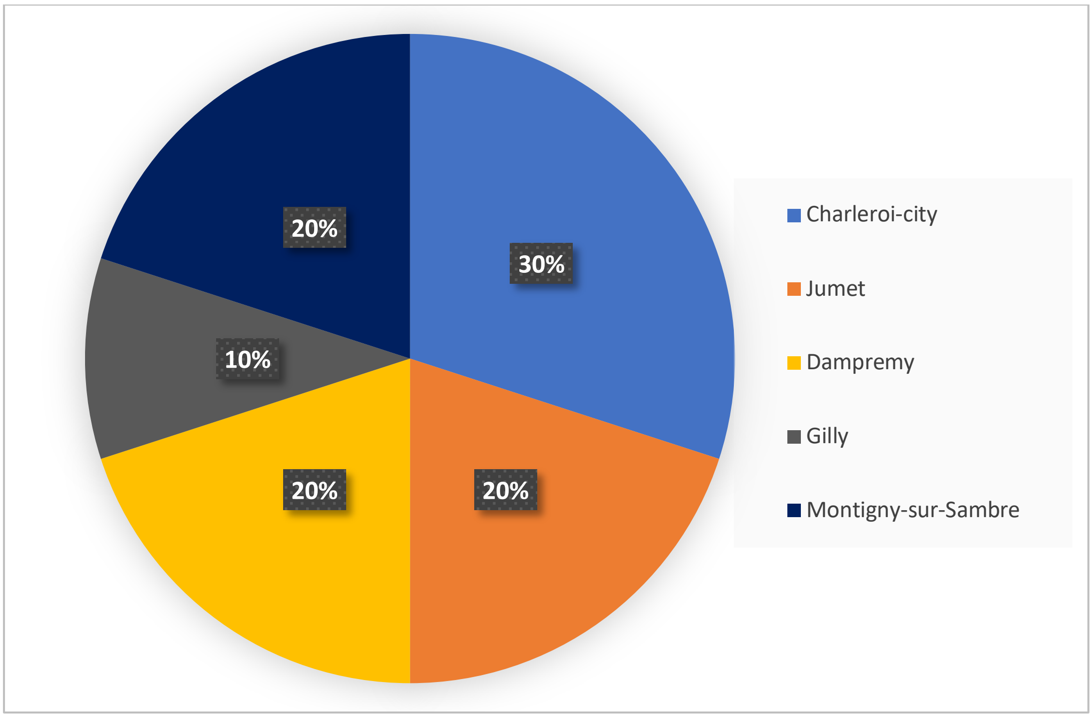
Graph 6: Patenting in the Belgian window-glass industry: geographical distribution of locations as indicated in patents, 1850-1910 (n=125)



Source: sample by Vitaly Volkov, see Appendix for the full list

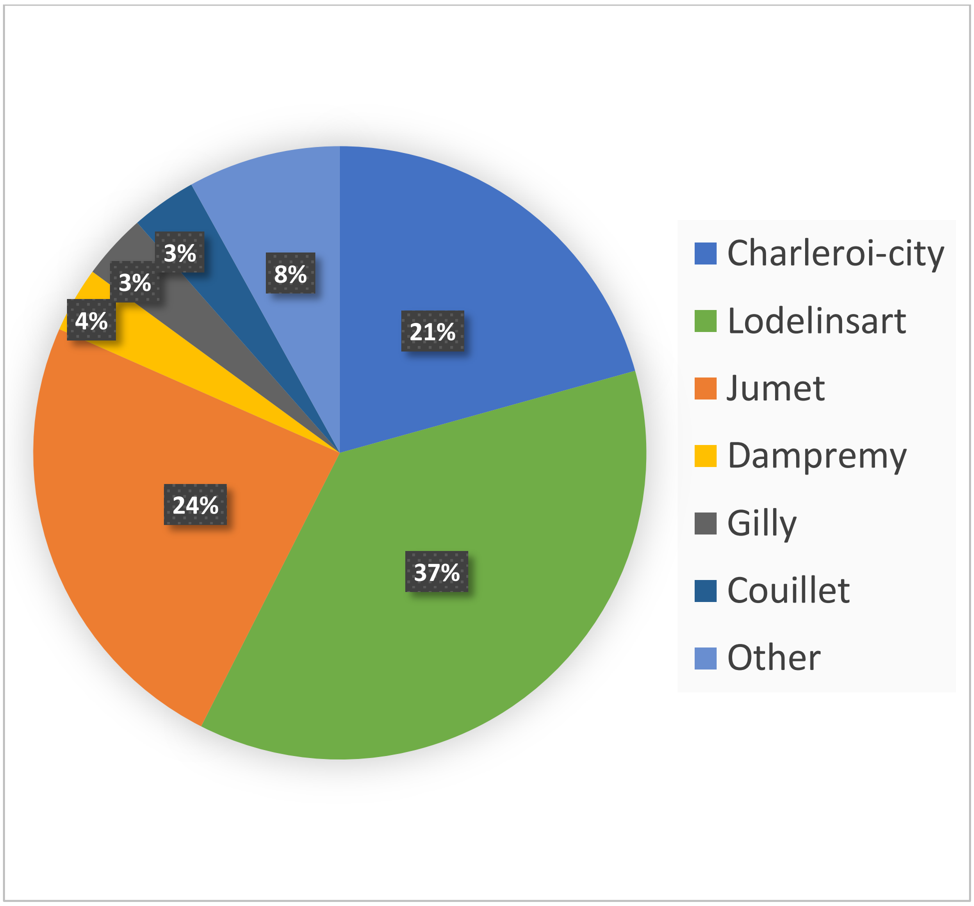
The diagrams (Graphs 7 and 8) make it clear that the majority of patents 'originated' within the Charleroi region, either as a place of registration of patent or a place of residency of inventors. This justifies an analysis on the even more local level of communes within the region.

Graph 7: Patenting in the Belgian window-glass industry: geographical distribution of locations in the Charleroi region as indicated in patents, 1830-1850 (n=10)



Source: sample by Vitaly Volkov, see Appendix for the full list

Graph 8: Patenting in the Belgian window-glass industry: geographical distribution of locations in the Charleroi region as indicated in patents, 1850-1810 (n=87)



Source: sample by Vitaly Volkov, see Appendix for the full list

Apart from Charleroi city, which was a regional centre but did not possess much industry within its municipal limits, most patents 'originated' in the nearby communes of Jumet and Lodelinsart, which possessed 60% of all the window-glass factories in Belgium around 1886[928] as well as in some other communes of the Charleroi region. Hypothetically, the overrepresentation of Charleroi could be due to its administrative role. While we do not know for sure, it is plausible that Charleroi possessed its own patenting office. If this was the case, the high share of Charleroi can be explained by the fact that patents were registered there, not by the fact that inventors lived there. On the results for locations such as Gilly or Couillet suggest that, at least in some cases, the inventor's residency was recorded as a location in the patents, as it seems unlikely that such small places possessed their own patent offices.

At any rate, the geography of patenting clearly reveals a very strong regional and even local embeddedness of inventive and innovative activity, and, most probably, a very close connection between innovation and production. While some patents 'originated' in Charleroi city (still only a few kilometres from the sites of industrial activity), many 'originated' in the industrial communes themselves. In the latter case the 'origin' can, most probably, be

[928] Poty and Delaet, *Charleroi pays verrier,* 72-73.

interpreted as the inventor's residency. It seems, therefore, that most patents were made by people who literally lived in the shadow of the factories, and quite possibly worked and 'buzzed' there as well. This is indicative of a closely-tied, locally-rooted community - a community that, as we have seen, emerged centuries earlier, and remained locally-embedded, for a large part, until the early 20th century, providing quite a striking example of continuity. Whether the location, as indicated in patents, referred to the place of registration or the inventor's residency, the analysis affirms that the majority of patents originated in the region itself.

Very few patents had their 'origin' outside the regions of Charleroi, Centre and Brussels. Between 1830 and 1850, one patent was registered in the region of Borinage (the city of Mons and surroundings), while between 1855 and 1910, six patents were registered in Namur, four in Borinage and one in Liège. Of these places, only Borinage had modest window-glass production. Namur and Liège lacked a window-glass industry altogether, but these cities featured a flourishing production of other types of glass (crystal and polished mirror-glass). Most probably, these patents can be seen as spillovers from other types of glass production. Hence, with the exception of Brussels, the geography of patenting reveals a very strong connection between production and innovation, reminding us of the concept of 'geography of knowledge'. This strong geographical embeddedness of knowledge and innovative activity is probably due to the high degree of 'tacitness' of knowledge within the glass industry during the period under study. This conclusion should be not seen as insignificant, as can be attested by the previously mentioned example of the United States glass industry between 1870 and 1925, as studied by Lamoreaux and Sokoloff, where the centre of innovation was located in southern New England, a region with very limited production. This paradox is attributed to the development of a 'market of technology' in such places, marked by the presence of patent agents and other intermediaries who traded in patent rights. In this context, Lamoreaux and Sokoloff even spoke of a 'separation, or division of labour, between invention and production.'[929] In Belgium, where the threshold for patenting was low, this seems not to have been the case (or at least to a much smaller degree), as intermediaries were not necessary. None of the Belgian patents within our sample mention patent agents, suggesting that inventors were able to fulfil all formal procedures for the submission of patents by themselves, or at least without formal assistance. It seems, therefore, that no 'market for innovations' developed in the Charleroi region itself, yet this does not mean that no such market existed in Belgium on a higher level. In particular, this seems to have been the case for Brussels. It did not possess any window-glass industry but recorded a significant (but by no means dominant) share of patents. This can be attributed to the fact that many patents originating in the Charleroi region, were registered in Brussels. This assumption can be confirmed in the cases of some well-known people who were clearly 'embedded' into the Charleroi region as industrialists or engineers, such as Baudoux or Oppermann, yet registered a part of their patents in Brussels (these cases are represented as 'Brussels/Charleroi' on the diagrams). It is possible that they possessed a (temporary) second residence in Brussels, or that they preferred to register their patents in the capital for reasons of social prestige. These patents do no mention intermediaries (patent agents). Yet, patent agents based in Brussels played an important role

[929] Lamoreaux and Sokoloff, "The Geography of Invention in the American Glass Industry," 702.

where foreign patents are concerned. This question will be discussed in the section on the functioning of patenting.

Knowledge in window-glass patenting

In order to better understand the limitations of patenting as a knowledge-management strategy, we need to distinguish between different types of knowledge, which will be done in this section. All of these types of knowledge were essential for the production of window glass, but the analysis will reveal whether patenting as a knowledge-management strategy was preferred for all of them or not.

For analytical purposes, three types of knowledge that may be expected to be present in the glass industry are distinguished (this distinction is inspired by, albeit not taken literally from, Joe Lane's work on knowledge in the Staffordshire Potteries,[930] as well as Petra Moser's work on propensity to patent in various industries[931]). These types are:

- 'Thermal knowledge': knowledge related to thermal technology, that is, in our case, melting furnaces (including melting pots) and annealers
- 'Mechanical knowledge': knowledge related to tools, machines and mechanical devices of all kinds
- 'Chemical knowledge': knowledge related to glass composition and chemical processes

As the annealers incorporated mechanical features (moving parts), they will be recorded as related to both thermal and mechanical knowledge.

Of course, the knowledge concerned does not have to be truly scientific. For instance, thermal knowledge as found in a patent did not necessarily imply that the patent holder had expert knowledge of the thermodynamics involved, nor did chemical knowledge imply a knowledge of analytical chemistry. The practical knowledge of furnaces or raw materials also often came without a 'scientific' background. The typology of knowledge within the patent sample is represented by the Graphs 9, 10, and 11.

A special note should be made relating to chemical knowledge. Moser mentions that Belgium (along with some other countries) did not have patents for chemicals in the 19th century.[932] This is incorrect, as the aforementioned published inventories explicitly included a category for chemicals, while applied chemical innovations could also be patented within the context of other industries, such as glass and ceramics.

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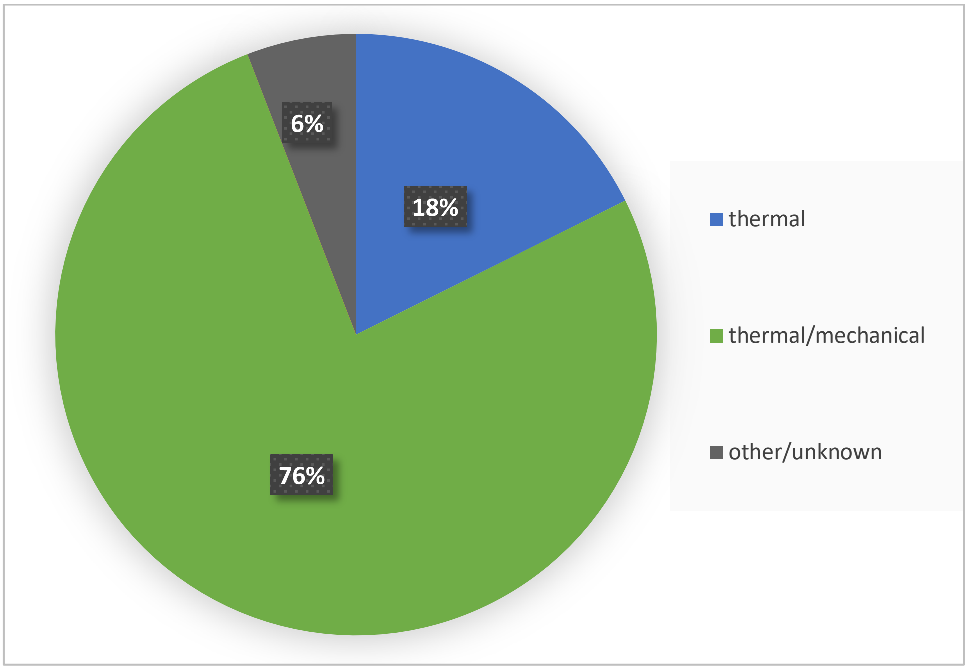
[930] Lane, "Secrets for Sale?" 876.

[931] Moser, "How do Patents Laws Influence Innovation?" 1221.

[932] P. Moser, "How do Patents Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs", In: *The American Economic Review*, 95:4 (Sep. 2005), p. 1217

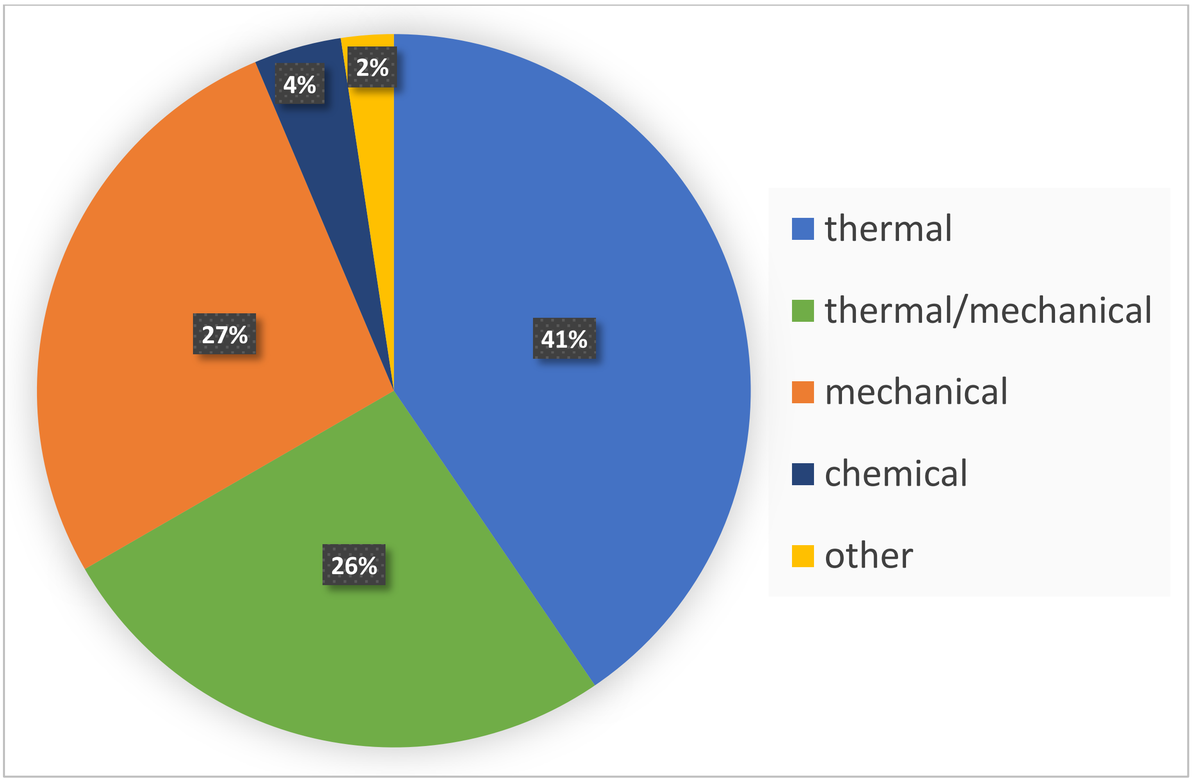
Graph 9: Patenting in the Belgian window-glass industry: typology of knowledge (Belgian patents), 1830-1850 (n=17)



Source: sample by Vitaly Volkov, see Appendix for the full list

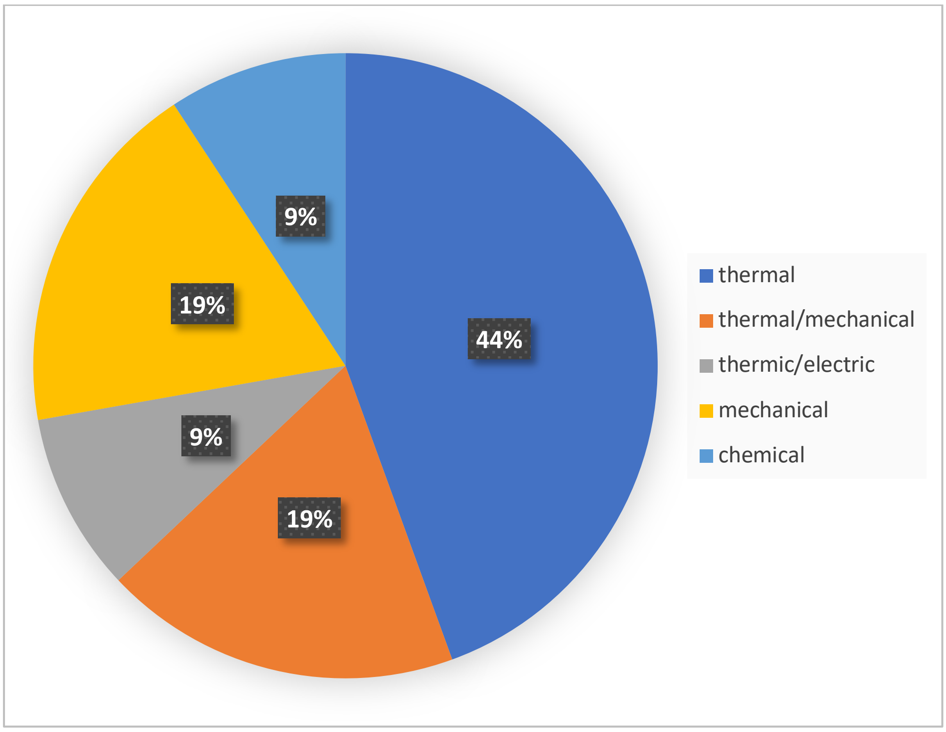
As for foreign patents, only four were recorded for the 1830-1850 period. Of these, three were within the 'other/unknown' category due to vague description, such as 'various improvements of glass production', while one belonged to the 'thermal/mechanical' category.

Graph 10: Patenting in the Belgian window-glass industry: typology of knowledge (Belgian patents), 1850-1910 (n=126)



Source: sample by Vitaly Volkov, see Appendix for the full list

Graph 11: Patenting in the Belgian window-glass industry: typology of knowledge (foreign patents), 1850-1910 (n=54)



Source: sample by Vitaly Volkov, see Appendix for the full list

It is apparent that ‘thermal’ and ‘thermal/mechanical’ are dominant for Belgian as well as foreign patents. Specifically, the propensity to patent (that is, to protect this type of knowledge in a formal way) was high for knowledge related to annealers and melting furnaces.

The category of purely ‘mechanical’ knowledge was less prominent for foreign patents than for Belgian. This is an interesting conclusion. For the largest part, this category included various small, simple and even ‘trivial’ devices, such as handheld tools. Apparently, foreign inventors deemed it less worthwhile to patent. Within Belgium, the ‘peak’ in patenting of such simple devices can be approximately located between 1870 and 1880. One of the first ‘trivial’ inventions in our sample, a device known as a *manique* (a kind of lever), was registered in 1870.[933] Many more followed in the next decades. However, patents for this kind of invention basically disappear after ten years.

Interestingly, the types of knowledge can, to some degree, be related to the social position of patent holders, although exact quantitative analysis is not possible. Unfortunately, Belgian patents do not provide information on the social position of patentees. Before 1855, some (but not all) patents mention it in very vague terms, such as ‘proprietor’ or ‘industrialist’. After 1855, even these indications disappear. Still, some deductions are possible. Many patents within the ‘thermal’ (furnaces) and ‘thermal/mechanic’ (annealers) categories can be attributed to the well-known industrialists and engineers (Baudoux, Frison, De Dorlodot, Schmidt, Oppermann, Gobbe). For the ‘mechanical’ category, i. e. more ‘trivial’ devices, the majority of patentees’ names are ‘unknown’ (not anonymous, but belonging to individuals who were not known as prominent personalities within the community). Given the fact that the majority of these patents were practical in nature, they were clearly conceived by people who were very aware of work methods, probably mid-range personnel or even workers themselves. A curious example is the *bloc de souffleur*. This humble piece of equipment (a kind of a mould) attracted a lot of attention. In 1880 alone, five patents for the improvements of *blocs de souffleur* were registered by five different patentees, all of them ‘unknown’ and all residing in the region of Charleroi (two in Lodelinsart and three in Jumet). The descriptions provided in the patents make it clear that the patent holders were very aware of the glassblowers’ work. It is not unimaginable that they were glassblowers themselves.[934] On the other hand, none of the foreign patents concerned *bloc de souffleur*.

The proliferation of ‘trivial’ patents in the later 19th century can be seen as indicative of the democratisation of patenting, the generally high propensity to patent and the positive patenting culture. The lowering of the threshold to patent in 1854 might also have been important.

As can be seen from the diagram on general trends, the number of Belgian patents fell dramatically after 1890, while the number of foreign patents grew. At the same time, new types of knowledge appeared in the foreign patents. The ‘thermic/electric’ category first appeared in 1890, when the German *Gesellschaft zür Verwertung der Patente für*

933 ARA-2, brevets, brevet nr. 27088 (1870)
934 ARA-2, brevets, brevet nr. 52090 (1880), nr. 52325 (1880), nr. 52360 (1880), nr. 53164 (1880), nr. 53257 (1880)

Glaserzeugung auf elektrischem Wege, Becker et C° from Cologne registered no less than three patents for electric glass-melting furnaces.[935] This kind of technology was not developed in Belgium. If invention patents are taken as an indicator, it seems that Belgian 'technological creativity' diminished quite suddenly after 1890. This is quite a striking conclusion, as the early 20th century is generally regarded as one of the finest periods of innovation within the Belgian glass industry, thanks to the development of the mechanical glass production process by Émile Fourcault.[936] There is no doubt that Fourcault's invention was one of the most important in the whole history of the glass industry.[937] However, the quantitative analysis of invention patents indicates that, paradoxically, by the time when Fourcault started his experiments in the early 20th century, the Belgian window-glass industry in general was already losing its innovative pace and starting to lag behind. It can be argued that Fourcault's invention reversed that trend, but this analysis would be beyond the chronological scope of this study. Alternatively, it can be proposed that the decrease in the number of patents is due to a decreasing propensity to patent rather than a decreasing rate of innovation itself. This seems an unlikely hypothesis, however. As mentioned, the propensity to patent grew steadily in late 19th-century Belgium. It seems doubtful that the window-glass industry would show an opposite trend.

When compared to the results for 'thermal' and 'mechanical' knowledge, patents relating to 'chemical' knowledge are underrepresented. From the samples between 1855 and 1910 (there were no chemical patents between 1830 and 1850), glass composition represents only 4% of the Belgian patents and 9% of the foreign patents. There are two possible explanations for this. On the one hand, if glass composition did not undergo much change in the 19th century, then there was simply no need to patent. However, as will be discussed in the chapter on technology, this was not the case, as important innovations to glass composition were introduced in the 19th century. Moreover, the knowledge of various glass components was even more important for the production of coloured glass and other types of special glass, such as opaque glass, which were among the specialties of the Charleroi region alongside ordinary window glass. Therefore, it is more plausible that other strategies were used for the management of chemical knowledge related to glass composition. These will be discussed in the section on disclosure and secrecy as these were, arguably, preferred strategies for the management of this type of knowledge.

The functioning of the patenting system

The quantitative analysis of invention patents as presented above provides us with several important conclusions. To begin with, the propensity to patent appears to have been high (with the exception of chemical knowledge). Of course, it is impossible to find the ratio between patented inventions and non-patented inventions as we simply do not have any indication of the number of the latter. However, as will be shown further in the chapter on the innovation of the production process, all important technological developments (melting furnaces and annealers) were represented by patents. Moreover, the proliferation of 'trivial patents' for very simple tools and devices reinforces the idea that the propensity to patent was high, and that patenting was popular in the community (including humble members).

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[935] ARA-2, brevets, brevet nr. 150783 (1900), nr. 151149 (1900), nr. 153676 (1900)

[936] Poty and Delaet, *Charleroi pays verrier*, 171-181.

[937] Cable, "The Development of Flat Glass Manufacturing Process," 27.

Another important conclusion is that patenting activity was strongly embedded locally. We are much less informed about the functioning of the patenting system beyond the mere registration of patents by the patent office. Yet some aspects of this functioning can be gleaned from the patents themselves, as well as from the *Association*'s proceedings. Patents themselves can give clues, in particular about the role of Brussels as a market for invention (including the role of patent agents) and as an innovation gateway. Furthermore, the *Association*'s proceedings offer us an insight into the attitudes towards patenting within the professional community in general as well as into the *Association*'s own role.

Brussels as a market for innovations

As mentioned, several inventors from Charleroi preferred to register their patents in Brussels. However, the role of Brussels as a market for innovations becomes much more prominent where foreign patents are concerned (*brevets d'importation* and Belgian *brevets d'invention* and *brevets de perfectionnement* registered in Belgium by foreign nationals directly or through representatives). Of all foreign patents (four for the period 1830-1850 and 53 for the 1855-1910 sample), only five were registered outside Brussels (one in Dampremy in 1837, two in Mons in 1880, one in Liège in 1880 and one in Liège again in 1905). It is therefore clear that Brussels started to play a role as an 'innovation gateway' and a 'market for innovation' from the 1840s on. The first foreign window-glass related patents were registered in Brussels in 1846, 1847 and 1848. By the early 20th century, the Brussels 'market for innovation' seems to have become truly well-developed. By that time, multiple patenting agents (individuals as well as, apparently, firms) were active in the city as representatives of foreign patentees. Examples include *De Visscher et Graetz*,[938] *Comptoir indus. et tech (anc. Maison Picard)*,[939] and *Raclot et Cie*.[940]

Unfortunately, before the 1890s the country of origin of foreign patents is very often unclear. Hence, the examples provided should not be taken as a quantitative measure. The patents registered in 1846, 1847 and 1848 were all English.[941] French patents were also common, for example two patents in 1855.[942] This is not surprising given the fact that these two countries, alongside Belgium, were the leading window-glass producers until the last quarter of the 19th century. From approximately 1880 on, two newcomers, Germany and the United States, gained importance in the global market.[943] This development is also reflected in foreign patents. Within our sample, these countries appear first in 1880 (Germany) and 1905 (United States) respectively.[944] Germany was especially prominent. German patentees who held patents in Belgium included Siemens and *Gesellschaft zür Verwerthung der Patente für Glaserzeugung auf elektrischem Wege, Becker et C°*.[945]

Yet the 'import of innovation' was not a one-way street. While the detailed study of the 'export' of Belgian innovations is beyond the scope of the present study, France can be given

[938] ARA-2, brevets, brevets nr. 147213 (1900) and 151411 (1900)
[939] ARA-2, brevets, brevets nr. 150783 (1900) and 151149 (1900)
[940] ARA-2, brevets, brevet nr. 223414 (1910)
[941] ARA-2, brevets, brevet nr. AC3652 (1846), brevet nr. AC3888 (1847), brevet numéro indicateur 5573 (1848)
[942] ARA-2, brevets, brevet numéro indicateur 1539 (1855); brevet numéro indicateur 2105 (1855)
[943] Mille, "Évolution de la branche verre plat," 76-86.
[944] ARA-2, brevets, brevet nr. 50309bis (1880) and brevet nr. 182038 (1905)
[945] ARA-2, brevets, brevet nr. 50309bis (1880), brevets nr. 150783 (1900) and 151149 (1900)

as an example. Several Belgian patents by Houtart, Bévez, Baudoux, Gobbe were registered in France from, at least, the 1860s.[946]

The *Association* and the functioning of the patenting system

On rare occasions, the *Association*'s proceedings offer us a glance into the functioning of patenting in the window-glass industry, the role of the *Association* in it and even the attitudes towards patenting within the professional community in general.
The earliest insight concerns a controversy around a patent on the 'washing of glass' (*lavage de verre*) by a certain Renard in 1869. The controversy was caused by the fact that many *Association* members did not consider this 'object' (technique) as eligible for patenting. Upon their demand, two lawyers had been consulted, both asserting the invalidity of this patent. The majority of the *Association*'s members considered this technique to be of general interest for the glass industry, and wished to, at least, consider the possibility of filing a lawsuit against Renard. Nevertheless, some members, including influential figures such as Dominique Jonet (the *Association's* President) and Casimir Lambert-fils were against any lawsuit. Not surprisingly, these were exactly those who had already established contracts with Renard. A special commission, consisting of Francart, J. Devillez, Hindel and Mondon was appointed to deal with the issue.[947] Surprisingly, no further mention of the lawsuit can be found in the proceedings, with one exception. As late as 1879, on the commemoration of the death of J. Devillez, the President reminisced that Devillez had played a crucial role in the lawsuit against Renard. The lawsuit that had eventually been won by the *Association* and even delivered a profit of more than one hundred Belgian francs to the *Association*'s members. Hence, apparently, the *Association* had succeeded in proving the ineligibility of this technique for patenting. Hereby, a sort of notion of 'public domain', belonging to all glass manufacturers, had been reaffirmed.[948]

Apart from the specific outcome, the discussion of this case reveals interesting points. It was asserted, that, a member had the right to deal individually with any inventor and without first obtaining authorisation from the *Association*, regardless of whether or not the inventor possessed a valid patent. It is not exactly clear what was meant by 'dealing with the inventor' - possibly, the 'buying of knowledge' (know-how), either protected by a formal patent or not, but this remains a guess. At any rate, it appears that the *Association* did not aim for the collective management of knowledge (know-how) at this moment, leaving it to the private initiative of its members. The principally liberal and non-interventionist character of the *Association* was reaffirmed in this context.[949]

The next mention of invention patents in the *Association*'s proceedings appeared in 1884 in connection with a new type of annealer invented by Biévez. Apparently, the adaptation of this important piece of equipment (the technical details will be discussed in the following

[946] Alba Fabiola Lozano Cajamarca, "Innovation des techniques verrières au XIXe siècle et leurs applications dans la réalisation de vitraux," 2 Vols (Unpublished PhD thesis (doctorat), Conservatoire National des Arts et Métiers, Paris, 2013), Vol. 1, 98-110.
[947] Private archive Gobbe, Association, Originaux A, Séance 27 mai 1869
[948] Private archive Gobbe, Association, Originaux C, Séance 25 août 1879
[949] Private archive Gobbe, Association, Originaux A, Séance 23 juin 1869, Quote: "Chaque membre du Comité [*Association* prior to 1873] pourra traiter individuellement avec tout inventeur, que le brevet de ce dernier soit ou non valable, sans devoir recourir pour cela à l'autorisation préalable du Comité"

chapter) had caused conflicts between the inventor and industrialists. Invoking his invention patents (*brevet d'invention* of 1866 and *brevet de perfectionnement* of 1867), Biévez demanded the payment of royalties amounting to 1200 Belgian francs for each annealer installed, up to the 9th January 1886. The *Association*, represented by Lambert, engaged in negotiations with Biévez, asking him to sell his patent rights so that all manufacturers would be able to use annealers free of charge. Unfortunately, it is not clear whether the settlement was achieved.[950] Nevertheless, this is an interesting case, as it provides the first example of a push for the collective management of innovation and an effort towards free dissemination of innovation within the community (*Association* members).

Moreover, this instance provides us with a very rare insight into the real functioning of the patenting system. On the one hand, Biévez can be regarded as a successful inventor, as he exploited his patent for the maximum term of 20 years (from 1866 until 1886), demanding considerable royalties. At the same time, the fact that a conflict occurred over royalties between him and industrialists, represented by the *Association*, illustrates that the functioning of patenting was sometimes contested.

The last recorded case concerns the introduction of tank furnaces or, more specifically, the invention patents issued to Léon Baudoux. It was mentioned for the first time late in 1889 and appears to have been the most important invention patent related case ever recorded in the *Association*'s proceedings, as it concerned a major innovation and was related to one of the leading firms within the industry. While the exact technical details (that is, the nature of the innovations concerned) were not recorded, the patents violated concerned the 'mode of working and shape of the bath' (*le mode de travail et la forme du bassin*) and some kind of 'floats' (*flotteurs*). The lawsuit was filed by Leon Baudoux, the patentee and inventor (see chapter on the innovation of the production process), who acted against the *Verreries de Jumet*, which had employed the aforementioned innovations illegally. Baudoux required this firm to pay him 'heavy compensations' (*lourdes indemnités*).

While the process itself did not concern the *Association*, Mondron, the *Association's* president decided to discuss the matter collectively. He was of the opinion that, if Baudoux were to win the case, he would subsequently 'attack' other manufacturers who found themselves in the same situation or were on the verge of this situation.[951] Therefore, Mondron considered this case to be of general interest. Moreover, he referred explicitly to the previously discussed case of Renard ('washing of glass').

The whole formulation used by Mondron implied that many manufacturers were applying these innovations 'illegally' without considering Baudoux's patents, while some were intending to do so shortly (i.e. were on the verge of 'this situation'). The quote makes clear that there were indeed practices of informally spreading innovations within the district in the late 19th century despite the general acceptance of formal patenting. Can this be seen as a remnant of an old culture of informal 'borrowing' and exchange of know-how from each other within the district? This may seem plausible, yet the lack of sources makes it

[950] Private archive Gobbe, Association, Brouillons II, Séance 25 juillet 1884 & 14 août 1884

[951] Private archive Gobbe, Association, Originaux C, Assemblée Générale 23 décembre 1889, Quote: "Si Mr. L. Baudoux gagnait son procès, il attaquernait les autres fabricants qui se trouvent dans le même cas ou sont à la veille de s'y trouver"

impossible to conclude with certainty. At any rate, during the discussion of the matter, nobody defended Baudoux's position. However, the argumentation referred to the fact that similar innovations had already been 'freely' used in foreign countries. Hence, the refusal to respect Baudoux's pretensions seems to have been motivated by contemporary (foreign) practices rather than by old traditions. Upon a vote, the *Association* had concluded that the issue was 'of general interest' and decided to support *Verreries de Jumet* financially in their litigation against Baudoux.[952]

The lawsuit against Léon Baudoux on the issue of invention patent dragged on for years and was finally won by the *Association* in May 1894. On the occasion, the president thanked L. Monnoyer for his support for the process, and É. Fourcault for his contacts with lawyers.[953] However, the 'saga' was still not over, as the case went into cassation in December of the same year.[954] The 'sequel' to the Léon Baudoux lawsuit is mentioned on a few occasions in 1895 without many details.[955]

These three cases give us some insights into the functioning of patenting. It appears that, despite the wide proliferation of patenting as a knowledge-management strategy, the *Association* dealt with them rather rarely. Yet, these occasions indicate that many of the *Association's* members effectively doubted whether a technique had truly been eligible for patenting at all. However, exactly because of the exceptional character of such cases, in contrast to the very large number of patents that were never questioned, it is possible to assume that patenting was generally accepted and respected. In my opinion, the aforementioned contested cases can rather be seen as the proverbial 'exception that proves the rule', as evidence is insufficient to speak of any kind of systematic 'collective invention' arrangement. However, the question arises as to what made these exceptions distinct from many other patents that were not opposed by the *Association*. In the first case (the 'washing' of glass by Renard), the main argument was the ineligibility of patenting for this technique. Speculatively, this could mean that the technique was not novel or original enough to merit a patent. Yet, the situation is different for the Biévez annealer and the Baudoux floats. In these cases, the notion of general interest was expressed more explicitly. This can be due to the great importance of both innovations for the Belgian window-glass industry as a whole, possibly in the context of tightening international competition, especially in the latter case. Hence, is seems that the *Association* was prepared to act as an organisation at the expense of individuals when collective interests were at stake. Moreover, the techniques concerned, especially the Baudoux-floats, were, apparently, difficult to keep secret and easy to reverse-engineer and copy, as suggested by the fact that they were used 'illegally'.

One can object by saying that the absolute majority of patents did not have any practical implementation anyway, and hence did not merit any discussion. Yet, many important innovations, such as annealers and melting furnaces, had been introduced (and patented) in these years. With only two exceptions (the Biévez annealer, and Baudoux floats), they had never caused any discussion within the *Association*. This shows that the Association only

[952] Private archive Gobbe, Association, Originaux C, Assemblée Générale 23 décembre 1889
[953] Private archive Gobbe, Association, Originaux C, Assemblée Générale 25 mai 1894
[954] Private archive Gobbe, Association, Originaux C, Assemblée Générale 17 décembre 1894
[955] Private archive Gobbe, Association, Originaux C, Assemblée Générale 15 mars 1895, Assemblée Générale 7 octobre 1895

intervened in the functioning of patenting when the common interest of the manufacturers was threatened. These were exceptions, however. It seems that in most cases, patenting was not questioned, suggesting that this strategy was generally accepted and respected.

Conclusion

Although this study is based on a limited (yet representative) sample, it clearly reveals the fundamental features of the patenting system within the glass-making community of practice within the Charleroi region. First and foremost, the propensity to patent was quite high from the beginning of the period on. Patenting became an even more widespread strategy in the later part of the 19th century (especially after the 1854 patenting law reform) with the proliferation of 'trivial' inventions, which were probably patented by people of more modest social standing. This is in line with the hypotheses based on the general character of the Belgian patenting system, that presented low threshold to patent due to the absence of preliminary examination and affordable registration fees. Interestingly, the 'trivial' inventions disappeared after ca. 1880. This can be attributed to 'scientification' or at least 'formalisation of inventive activity' as represented by the shift from the 'mechanic inventor' to the 'scientist inventor' discussed in the context of patenting culture.

However, the propensity to patent varied significantly depending on the type of knowledge. While patents on 'thermal knowledge' (melting furnaces and annealers) and 'mechanical knowledge' are abundant, patents on 'chemical knowledge' (glass composition) are almost non-existent. As will be further argued below, this paradox can be explained by the role of other knowledge-management strategies such as secrecy and disclosure and will be discussed further in the context of other knowledge-management strategies.

The study of patents and other sources reveals an interesting, and even paradoxical, image of the community. This community, that came into being in the centuries before the 19th century by means of migration, remained strongly locally embedded, as is attested by the geography of patenting. At the same time, the dominant attitude seems to have been rather individualistic, as is exemplified by the high propensity to patent (albeit not for chemical knowledge) and the absence (or near-absence) of disclosure and collective invention (see next paragraphs). This can, at least partly, be explained by the specific nature of entrepreneurship within the Belgian window-glass industry. One influence was the weight of a limited number of established families (for instance, de Dorlodot) forming entrepreneurial dynasties for generations, often tracing their origin back to the times of *gentilshommes verriers*. However, more humble members of the community (possibly even workers themselves) also quite often employed the patenting strategy , as is attested by the 'trivial' patents. Therefore, the general proliferation of patenting in Belgium, the low threshold (especially after the 1854 reform) as well as positive attitudes towards patenting (patenting culture) can provide a more general explanation. It can therefore be argued that the individual agency played a major role in the knowledge-management.

Despite the wide spread of patenting, some patents became contested, as exemplified by the actions of the *Association*, providing examples of collective agency. The general interest of the entrepreneurial community seems to have been the major incentive here.

On the national scale, the geography of innovation was largely limited to the glass-producing regions of Charleroi and Centre, hence indicating strong ties between innovation and production. At the same time, Brussels already played an important role as an 'innovation gateway' and 'market for innovation' from the 1840s on. By the late 19th century, these roles became even stronger, as is exemplified by multiple patenting agents who were active there. These agents played a key role for the 'import' of foreign innovations, but were of less (or no) importance for Belgian inventors, at least in the context of the window-glass industry. The share of foreign patents increased significantly in the late 19th century.

Disclosure and secrecy

Compared to patenting, other knowledge-management strategies, especially disclosure and secrecy, are much less represented in sources. The *Association*'s proceedings mention the informal sharing of information quite explicitly on one occasion only. More precisely, it is to be found in a eulogy to the memory of Casimir Lambert (1827-1896), delivered in 1896 by Émile Fourcault. According to this source, Lambert, while being 'a convinced individualist' who preferred to rely on his personal labour, had been willing to share his know-how with his *confrères* (colleagues, glass manufacturers in this context). If we are to believe Fourcault's words, Lambert's factory even acted as a huge school for his colleagues.[956]

Nevertheless, some insights can be gleaned or deduced from sources (or even from the absence from certain sources), albeit in an indirect way. These sources include published contemporary treatises on glass production, some other publications, the *Association's* proceedings and three unique notebooks. These last are three handwritten notebooks that are preserved at the Glass Museum (Musée du Verre) in Marcinelle near Charleroi and the Museum of Old Techniques (Museum voor Oudere Technieken) in Grimbergen near Brussels. The two notebooks from the Glass museum ('thin' and 'thick') are anonymous, while the notebook from the Museum of Old Techniques belonged to Oppermann. The anonymous notebooks date from the late 19th-early 20th centuries and are directly related to the practical aspects of the work. Presumably, they were held by middle-ranking technicians. All three of these notebooks contain multiple recipes for window glass composition, for both 'clear' (colourless) glass and various coloured and special glasses.[957] It is worth emphasising how these notebooks differ from published treatises. The notebooks were created outside the formal framework of knowledge transmission, such as publishing houses and the like. They were most probably intended for personal use, although their use for the sharing of information is also plausible. All in all, they attest to practical (partly tacit) knowledge on the work floor, different (possibly even richer to some degree) from that found in published treatises.

Disclosure by the means of publications

Before we direct our attention exclusively to Belgium, it is useful to look at knowledge management in the glass industry in a broader perspective. Paradoxically, both secrecy and

[956] Private archive Gobbe, Association, Originaux C, Assemblée Générale 30 novembre 1896
[957] Archives Musée du Verre, Charleroi, Unclassified documents, two notebooks: 'Thin' notebook, initiated in 1903, archive code DIV58 and 'Thick' notebook, initiated in 1910, no archive code; Documentation centre of the Museum voor Oudere Technieken (Grimbergen, Belgium), Document 08/322 (notebook Oppermann)

public disclosure can be regarded as long-standing traditions of the glass industry, at least from the Late Medieval and Early Modern times onwards. The best-known example of the former strategy is the Venetian policy of keeping secret the know-how of its famous glassblowers. In order to prevent any dissemination of valuable knowledge, the emigration of glassblowers was strictly regulated by Serenissima's government, although it did not succeed completely in forbidding emigration, and hence the spread of knowledge.[958]

On the other hand, numerous treatises on glass production, including composition and production methods, were published in Europe starting with Antonio Neri's *Ars Vitraria* (1612). The popularity of such works can be attested by the fact that they were often republished and translated. However, many of such Early-modern texts were written (or rather copied and compiled) by people who had very little (if any) practical experience with glass production. It was only by the late 18th century that more accurate treatises started to appear.[959] According to C. Loysel, who published his own treatise in 1791, the work of Neri (and, implicitly, of others) was still 'not scientific'. It was only from later decades (that is, the second half of the 18th century), that progress in that respect had really taken place, thanks to the development of chemistry which could provide a scientific basis for the study of glass.[960] However, this assessment needs to be put in perspective. While they obviously did not fit the scientific standards of the 19th century, authors of some treatises, such as Merret (*The Art of Glass*, 1662), Kunckel (*Ars Vitraria experimentalis*, 1689), baron D'Holbach (*L'Art de la Verrerie*, 1752), as well as Neri himself, based their recipes on practical experiments. As demonstrated by experiments carried out by Joost Caen in the context of his academic research as well as his conservation and restoration practice, many of the recipes provided by these authors are, indeed, practical. Many other authors, however, did not contribute their own research, merely copying and compilating older works.[961]

In the 19th century, many important works were published in France, England and German-speaking countries. Probably the most influential of all was *Guide du Verrier* by Georges Bontemps. Bontemps was a glass technologist, as were many other authors of similar works in this period.[962]

Despite the lack of hard evidence, we may assume that French treatises were known in Belgium because of geographical proximity and the shared language. The Belgian glass industry was almost exclusively located in the French-speaking part of Belgium during the period under consideration (and even within the Dutch-speaking part of Belgium, French was a language of social elites in the 19th century). It is known, for instance, that the manuals of the French *Manuels Roret*-series were known and used in Belgium in the 19th century.[963]

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958 Frumkin, "The Origin of Patents," 143.
959 Caen, *The production of stained glass,* 38-40.
960 C. Loysel, *Essai sur l'Art de la Verrerie* (Paris, n.p. 1791), xiii-xiv.
961 Communication by Joost Caen (01 July 2022, by email); Caen, *The production of stained glass*, 38, 82-83.
962 Cable, "The classic texts of glass technology," 61.
963 Michel Dorban, "Circulation et diffusion du savoir et de l'information techniques aux XIX^{e} et XX^{e} siècles. État de la question," in *Innovation, savoir-faire, performance. Vers une histoire économique de la Wallonie*, ed. Kenneth Bertrams (Charleroi: Institut Jules Destrée, 2005), 114.

One of the manuals within this series, *Manuel complet du verrier et du fabricant de glaces, cristaux, et*c by J. de Fontenelle (first published in 1829) was dedicated to glass production.[964]

It can therefore be assumed that Belgian window-glass manufacturers used the disclosure strategy 'passively', that is, as receivers of treatises published elsewhere. As for the 'active' employment of this strategy, that is, writing and publishing treatises themselves, it appears that Belgian glass technologists and industrialists were reluctant to follow the example of their French (and other foreign) colleagues. The already-familiar figure of André-Marie Oppermann can serve as a fine example in this respect. While he accumulated a vast amount of knowledge in the course of his professional life, I could not find any treatises on glass production or other technical publications of his authorship. This attitude seems typical of the business culture of the glass-making community in Belgium, where the public disclosure of knowledge through publications seems to have been largely absent. As mentioned above, many foreign (mostly French) treatises containing recipes as well as other information were accessible in Belgium, yet nothing comparable was published in Belgium itself before 1914. Not one of the leading 19th century glass industrialists and technologists, such as Léopold de Dorlodot or Eugène Baudoux deemed it necessary to publicly share their knowledge.

Of course, from the philosophical point of view, proving a negative (proving absence) with certainty is problematic, if not impossible. In order to track possible treatises or other contemporary Belgian publications on glass production, searches were undertaken using the names of the most important Belgian glass industrialists and technologists as well as keywords. Sources included catalogues of Belgian scientific libraries, such as the Royal Library of Belgium alongside Belgian and foreign university libraries. Apparently, some of Belgian glass industrialists were prolific writers. Henri Lambert published several books and dozens of articles, mostly on social, political and economic issues. However, he dedicated only few short newspaper articles to the glass industry. Bibliographies were also consulted, such as the basic bibliography provided by Engen, as well as literature lists found in publications by Chambon, Poty and others.[965] The fundamental bibliography of glass by Willy Van den Bossche was of special importance. It contains multiple references to foreign (mostly French and German, alongside a few English and American and a single Italian) treatises on glass production and technology published in the 19th century, yet not a single Belgian one. This is all the more remarkable because the author of this work is Belgian, making it rather unlikely that he would had overlooked any relevant Belgian work.[966] It can therefore be concluded with a high degree of certainty that no treaty on glass production and technology comparable to foreign examples was written, or at least published in Belgium in the 19th and early 20th century up to 1914.

The only known attempt to write a general treatise on glass in 19th century Belgium is a curious case recorded in the *Association*'s proceedings of 1869-1870. It concerned a certain Mr. Lyon-fils (unfortunately, the first name is unreadable) who would have written a book on glass, in particular, its history, production, trade and the development of the glass industry in

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[964] Julia De Fontenelle, *Manuel complet du verrier et du fabricant de glaces, cristaux, etc*. Manuels Roret (Paris: Roret, 1829)

[965] Engen, *Het glas in België,* 435-436, supplemented by own heuristic research

[966] Willy Van den Bossche, *Bibliography of Glass. From the Earliest Times to the Present* (n. p., n. p., 2012 [first edition – printed book], 2019 [updated and extended digital edition])

Belgium in general. Together with a certain (another) Lyon, a lawyer from Charleroi (most probably his father, first name not mentioned), he contacted the *Association* at the end of 1869, offering his manuscript for the price of 250 Belgian francs. The *Association* formed a commission composed of Edouard de Dorlodot, Bastin (no first name mentioned) and Casimir Lambert-fils that would study the manuscript in order to decide whether it was of any interest, and to deal with the author.[967] Somewhat later, in February 1870, Casimir Lambert-fils declared at the *Association*'s meeting that he had met Lyon-fils and had even given him some documents on the origins of the Belgian glass industry, so that Lyon-fils could complete his manuscript. It was understood that, after the completion of his work, Lyon-fils would present it to the *Association*.[968] Unfortunately, Lyon-fils and his work were never mentioned in the *Association*'s proceedings or any other source afterwards. The work itself, even if it was ever finished, remains without any trace, as I could not find anything in any bibliography or library catalogue.

While the *Association* showed some moderate interest (and even assistance) for this work, this instance is illustrative to the general reluctance of the 19th-century Belgian glass manufacturers to share their knowledge via publication. Indeed, the above, the only known initiative to this end was undertaken (most possibly, unsuccessfully) by an outsider without any apparent connection to the industry save for the location (as the lawyer Lyon, most probably the author's father, was described as 'of Charleroi').

Publications on the Belgian glass industry started to appear in various forms in the latter part of the 19th and early 20th centuries, in the form of articles in specialised and general press, reports from national and world fairs and treatises on the Belgian economy in general. One of the first (if not the first) example was a report on the state of the glass industry written by Léon Mondron, a prominent Belgian glass manufacturer, for the 1873 Vienna World Fair.[969] This report included some technical details alongside a general discussion of the state of the industry. Similar reports accompanied most of the World Fairs held, as the Belgian window-glass industry was almost always present. However, most of them were concise and did not provide much detail. The most detailed report was published as a result of the 'unofficial' Fair of Charleroi of 1911 (held as an international fair, but not recognised by the *Bureau International des Expositions* retroactively).[970] Here, again, some technical details are provided. Another strain of publications that started to appear in the early 20th century, focused on the economic situation of the window-glass industry. Examples include articles of H. De Nimal (1904), O. Misonne (1905) and A. Lalière (1913).[971] While some technical details were provided, none of these publications placed them at the centre of attention.

Of particular interest is a monograph on the Belgian glass industry that was published by the Belgian government in 1907 as a part of the *Monographie industrielle* series.[972] The purpose of this book was to provide an overview of all aspects of the glass industry, including the

[967] Private archive Gobbe, Association, Originaux A, Séance 13 décembre 1869
[968] Private archive Gobbe, Association, Originaux A, Séance 21 février 1870
[969] Léon Mondron, *Exposition universelle de Vienne 1873. Industrie de la verre* (Brussels: Guyot, 1874)
[970] Drèze, *Le livre d'Or de l'exposition de Charleroi*
[971] De Nimal, "L'industrie du verre à vitres en Belgique"; Misonne, "La crise verrière dans le bassin de Charleroi" ; Lalière, "Le verre en Belgique."
[972] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*

technology. Despite their value, when compared to the aforementioned works by Bontemps and other foreign examples, these works were intended to inform outsiders on the state of the industry, rather than to provide a practical manual for people active in the industry and to share technical details. The only type of publications from before 1914 that can be compared to French (and other foreign) treatises in the objective of providing practical information to the 'insiders' active in the industry, are short articles that started to appear in local newspapers from the early 20th century on. For example, in 1910 the Charleroi newspaper *Moniteur Industriel* published an article on the production of green glass, providing the chemical composition alongside some practical tips. Interestingly, this information was foreign, as the newspaper cited the National Glass Budget, Pittsburgh (United States) as the source. This example illustrates the role of this periodical for the sharing and dissemination of technical knowledge, as well as the growing interest in foreign innovations, this will be discussed further on.[973]

By the early 20th century, specialised trade press also started to appear. For example, *Industrie du Verre: moniteur industriel, technique, commercial et financier de la glacerie et de la verrerie* started publishing in 1914.[974] The initiative for this publication did not originate from the *Association* itself, but from a certain Mr Basquin d'Essarts, who asked for the *Association's* support for this publication in February 1914.[975] Moreover, this journal emerged rather 'late' when compared to other industries. To put matters in perspective, the *Revue Universelle des Mines* (mining industry) had already in 1857. However, this was an early exception, as the true boom in industrial press in Belgium originated in the 1870s and 1880s. These included specialised journals dedicated to single, specific industries, such as *Bulletin de la Société belge d'électriciens* (electric technology, started publishing in 1884), and general industrial journals such as the *l'Ingénieur Conseil* (1878), *l'Industrie Moderne* (1887) and *l'Industria* (1889), which merged into *l'Industrie* in 1889. The development of industrial press was a consequence of the increasing role of science at the expense of traditional skills and tacit knowledge during the period known as the second industrial revolution. The development of technical education, such as industrial schools (*écoles industrielles*), was another aspect of this process.[976]

Obviously, these short publications are not comparable to extensive treatises. An interesting exception is a four-volume unpublished treatise *Traité de la fabrication du verre* (Treatise on the production of glass) written by Émile Fourcault in the early 20th century (dated 1912). This manuscript is preserved in the Musée du verre in Charleroi, but, because it remained unpublished, we are not sure how 'public' this work was intended to be.[977]

Disclosure by the means of education

As will be discussed further in Chapter 3.3, from the second half of the 19th century on, Charleroi and its surrounding towns possessed a number of industrial schools, intended to

[973] *Moniteur industriel*, 22 janvier 1910
[974] Engen, *Het glas in België,* 435.
[975] Private archive Gobbe, Association, Originaux D, Assemblée Générale 9 février 1914
[976] Jean-Marie Wautelet, "Les revues industrielles dans la conjoncture économique du 19e siècle," *Alliance Industrielle*, numéro du centenaire (October 1980): 71-76.
[977] Poty and Delaet, *Charleroi pays verrier*, 184-185.

provide additional theoretical education for labourers. A central institution for the 'learning and improvement' of workers of the Hainaut province, known originally as the Provincial Industrial high school (*École industrielle supérieure provinciale*) was founded in Charleroi in 1903 by Paul Pastur, a Walloon politician and lawyer. In 1911, it was transformed into a University of Labour (*Université du Travail*), where the name 'university' was symbolic, as the institution had never acquired the formal status of university. The University of Labour remained largely dedicated to various kinds of professional education, targeted, primarily, at working-class students.[978] However, as established from the *Association*'s proceedings, the University of Labour offered courses intended for industrialists themselves and their senior personnel. In February 1912, the Director of the University of Labour asked for the *Association's* support for the organisation of a course called 'Glass from the physical and chemical point of view' (*Le verre au point de vue Physique – Chimique*), to be taught by Emile Fourcault. The course of seven lessons would be taught on Sundays starting from the 18th February. All members supported the initiative, while the *Association*'s president congratulated Fourcault on this initiative and encouraged all members to attend the course personally or to send representatives of their personnel.[979]

This is an interesting case whereby one of the *Association*'s members, Fourcault, used an infrastructure provided by the government to share and disseminate knowledge among his colleagues and most probably to a broader public as well, albeit, to our knowledge, it remains unique.

Chemical composition: a special case of knowledge-management

As mentioned in the discussion of patenting as a knowledge-management strategy, chemical knowledge presents an interesting case, as it was almost completely absent from invention patents. From the perspective of Mosers' theory, it seems plausible that this type of knowledge was not protected by patents as, given the difficulties in reverse-engineering glass composition, requiring complicated chemical analysis, secrecy must have been a better strategy. The case of Staffordshire potteries, where chemical knowledge was generally kept secret, while the design of furnaces was often patented, strengthens this hypothesis (secrecy hypothesis).

However, an alternative explanation for the relative lack of patents for glass composition can be that it was already widely known, and hence not worth patenting. To put it simply, we need to understand whether glass composition was a 'well-kept secret' or 'common

[978] Jean Boets, "L'enseignement technique. Quelques promoteurs et leur réalisations," in Tome IV, compléments of *La Wallonie. Le pays et les hommes. Lettres, arts, culture*, eds. Rita Lejeune, Jacques Stiennon and Rita Lejeune-Dehousse (Brussels: La renaissance du livre, 1981), 275-276; Paul Delforge, "PASTUR Paul," Connaître la Wallonie, accessed 13 July 2022. http://connaitrelawallonie.wallonie.be/fr/lieux-de-memoire/pastur-paul-0 ; Paul Delforge, "Paul Pastur," Connaître la Wallonie, 2011, accessed 13 July 2022. http://connaitrelawallonie.wallonie.be/fr/wallons-marquants/dictionnaire/pastur-paul ; Paul Delforge, "28 mai 1911 : Inauguration des nouveaux bâtiments de l'Université du Travail à Charleroi," Connaître la Wallonie, accessed 13 July 2022. http://connaitrelawallonie.wallonie.be/fr/histoire/timeline/28-mai-1911-inauguration-des-nouveaux-batiments-de-luniversite-du-travail ; Michel Géoris, "PASTUR, Paul," in Tome 8 of *Nouvelle biographie nationale* (Brussels: Académie royale des sciences, des lettres et des beaux-arts de Belgique, 2005), 299-300.

[979] Private archive Gobbe, Association, Originaux D, Assemblée Générale 2 février 1912

knowledge', as, paradoxically, both alternatives can provide an explanation for the relative lack of chemical knowledge in patents. To do so, we turn our attention to two kinds of sources, the published treatises on glass production and Belgian notebooks.

From the 18th century on, many treatises on glass production were published in France and other countries, and it seems likely that they were known and used in Belgium as well. The oldest of the treatises in our sample is the *Essai sur l'art de la Verrerie* by Loysel (1791). This work provides basic compositions for window-glass of various qualities, such as 'verre à vitres commun' (lower quality) and 'verre à vitre blanc' (higher quality). The same work also provides the basic compositions for coloured glass.[980] Interestingly, according to a later treatise by De Fontenelle (1829), Loysel was the first author to write about glass composition from a 'scientific' perspective.[981] De Fontenelle himself provides an extensive overview (almost hundred pages) of various chemical components that were used in glass production, along with example compositions of both ordinary and coloured glass.[982]

The compositions (recipes) became even more elaborated and detailed in the *Guide du Verrier* by Georges Bontemps (1868). In this treatise, Bontemps provided basic components for ordinary as well as coloured glass. For ordinary window glass, Bontemps provided a couple of 'outdated' compositions dating from before the introduction of artificial soda, as well as two 'contemporary' French and two 'contemporary' English compositions.[983] As for coloured glass, he provided several basic compositions for each colour-group (blue glass, violet glass, yellow glass, green glass and red glass). For example, for yellow glass Bontemps provided one basic composition and three variations for distinctive shades. The same applied to other colour-groups. The main components were basically the same as in the works of Loysel and De Fontenelle, but Bontemps provided more variations. It is not possible to tell exactly how many recipes Bontemps provided, as he often mentioned that some components might be adjusted or replaced by others, leaving some space for experimentation on the part of the end user.[984] In all, the total number of compositions was around thirty.

Last but not least, the treatise of Léon Appert and Jules Henrivaux (1894) not only provided basic compositions of window glass, but even gave examples of recipes that were in use in Germany, Belgium, England and France. They also gave much attention to the compositions of coloured glass.[985]

These four examples of treatises, ranging from the late 18th until the late 19th centuries, suggest that basic glass compositions, including coloured glass, were not a secret. Interestingly, however, Bontemps mentions that, in general, glassmakers tended to keep the composition of glass vague to outsiders, or they even provided downright wrong information in this matter.[986] He also notes several times that the exact proportion of components may

[980] Loysel, *Essai sur l'Art de la Verrerie,* 152-160, 217-225.
[981] De Fontenelle, *Manuel complet du verrier,* 5-6.
[982] Ibidem, 34-120, 211-252.
[983] Bontemps, *Guide du Verrier*, 235-245.
[984] Ibidem, 333-372.
[985] Léon Appert and Jules Henrivaux, *Verre et verrerie.* Encyclopédie industrielle (Paris: Gauthier-Villars et fils, 1894), 243-246, 386-402.
[986] Bontemps, *Guide du Verrier*, 206.

vary depending on what shade is required. He notes as well that the production of coloured glass should not be taken lightly, as it required a certain amount of 'practical knowledge and organisational skill' from the glassmaker.[987] Clearly, apart from the knowledge that was freely accessible from books, there was still a certain amount of less formal, tacit knowledge required for production.

A glimpse into the practical and tacit chemical knowledge and the way it was managed is offered by the three notebooks, described at the beginning of this section, the Oppermann-notebook and the two anonymous notebooks.

The Oppermann-notebook contains just over ten recipes for coloured glass. The anonymous 'thin' notebook, on the other hand, contains more than fifty recipes. Here again, the exact number is hard to pinpoint, as the distinction between 'variants' is sometimes difficult to establish. Quite often, the notebook provides multiple composition variants for the same colour, what can be regarded as a testimony of practical experience and experimentation. If regarded 'liberally' (that is, counting all variants), the total number of recipes amounts to hundreds, but even when considered 'conservatively', several dozens of compositions can be distinguished. Moreover, this notebook contains multiple practical instructions and observations on the production of coloured glasses, as well as detailed information on chemical components.[988] The 'thick' notebook, contains compositions and instructions for the fourteen 'basic' types of coloured glass along with a couple of dozens of 'shades'.[989]

Most probably, these notebooks were intended for personal use. On the other hand, it seems plausible that they recorded knowledge that was circulating ('buzzing' in Bathelt's terms) within the community in an informal way. Although only three notebooks survive, it appears likely that many more have existed. While this assumption will remain an educated guess, it can be imagined that those who kept these notebooks adjusted 'recipes' based on their own practical experience. To what degree these 'secrets' were shared with other will remain unknown due to the lack of other sources.

All in all, these notebooks point to a rich range of practical and tacit knowledge that was present within the community. Hence, in my opinion, the 'common knowledge vs well-kept secret' paradox can be resolved as follows. The basic glass compositions (including for coloured glass) must have been well-known and freely accessible from open sources, such as various treatises and manuals (common knowledge). However, some (minor) variations, alongside practical 'tips and tricks' (tacit knowledge) may have been managed and shared informally, possibly with some degree of secrecy, as exemplified by the notebooks. Paradoxically, the management of chemical knowledge was thus determined by the interplay of two opposing factors.

The evolution thereof may have been related to the possibility of 'reverse-engineering' glass composition, that is, of conducting chemical analysis of glass. As chemistry made significant

[987] Ibidem, 206, 335-336

[988] Archives Musée du Verre, Charleroi, Unclassified documents, 'Thin' notebook, initiated in 1903, archive code DIV58

[989] Archives Musée du Verre, Charleroi, Unclassified documents, 'Thick' notebook, initiated in 1910, no archive code

developments during the 19th century, applied 'glass science' developed as well. Already in 1868 Bontemps described a process of chemical analysis of glass composition, even a rather complicated one.[990] In 1894, Appert and Henrivaux described two methods of glass analysis, one that was quite precise, but long and complicated, and another that was somewhat less precise, but still quite satisfactory. Interestingly, they call the latter 'the industrial method', suggesting implicitly that it must have been common in industrial settings.[991] Hence, the possibility of reverse-engineering chemical innovations improved by the end of the 19th century. Yet, it does not seem to have changed patenting practice much until the First World War. At any rate, chemical knowledge was still more difficult to reverse-engineer than mechanical or thermal knowledge. In the former case, a strictly scientific, laboratory-based analysis was required, while in the other cases an attentive observation would often suffice.

We can conclude that the reluctance to patent chemical knowledge can still, at least partly, be explained by the theory of Moser, as it was difficult to reverse-engineer and easier to keep secret. However, this logic applied to the 'fine tuning' only, as the basic compositions were widely known. Moreover, the high degree of 'tacitness' of this knowledge possibly made it relatively safe to share it within the professional community, as an outsider without practical experience must have had difficulty in applying it in practical way, even if he managed to gain this knowledge by one means or another.

The collective management of knowledge and innovation

The last knowledge-management strategy to be discussed after patenting and disclosure and secrecy, is collective invention. Yet, as indicated above, the industrial region and glass-making community of Charleroi lacked the practice of free disclosure of technical information by participants (firms) through open publication. As described in works by A. Nuvolari on the Cornish pumping engine and of C. Allen on blast furnaces, open publication is regarded as a key element in the collective invention strategy.[992] However, this does not need to imply the absence of any collective mechanisms for the sharing of knowledge. In particular, it seems plausible that the *Association* played an important role in this respect, as it provided a meeting and discussion platform for most manufacturers of the region. This justifies the redirection of attention from the knowledge-management strategies in the district in general to the more specific role of the *Association* in this matter. Moreover, the international contacts of this organisation have already been acknowledged in a previous Part. However, the analysis of the *Association's* proceedings reveals that, apart from very few exceptions, the question of technology did not feature high on its agenda until the very last years of the 19th century.

As will be shown in the following paragraphs, the *Association* interfered in the dissemination of knowledge of innovations among its members, but did not engage itself with the practical implementation of innovations in industry, leaving that to individual members. The question of practical innovations of the production process will be addressed in the following chapter.

[990] Bontemps, *Guide du Verrier*, 206-217.
[991] Appert and Henrivaux, *Verre et verrerie*, 59-66.
[992] Nuvolari, "Collective invention during the British Industrial Revolution: the case of the Cornish pumping engine"; Allen, "Collective invention"

The following paragraphs will discuss the *Association*'s engagement with know-how, in the first place with the acquiring of new technologies from foreign sources. Hereby, the 'content' (specific technical detail) is of lesser importance.

The *Association* and technological innovation

The first instances of the *Association*'s engagement with technology can already be found during its first years of existence shortly after 1848, when it demanded that the provincial government abolish the so-called patent tax on the mills for the crushing of raw materials, that were described as an indispensable pieces of equipment for glass factories. Apparently, despite several petitions, no success had been achieved.[993] This patent tax concerned the right to use several types of machinery and industrial equipment, such as steam engines for example, and should not be confused with invention patents.[994] This concerned a purely fiscal issue, having little, if any, impact on the development and spread of new technology in itself.

The *Association* showed some awareness of technological developments abroad for the first time in 1868, when it discussed the rise of a window-glass industry in Saarbrücken and Westphalia, that started to threaten the Belgian position in the German and Swiss markets. The *Association* attributed this development to the 'improvements of production' that had been implemented there. In order to catch up, it was declared necessary to go and study these new developments. Even more remarkably, it was stated that only ten years earlier, when the German glass industry was 'inferior' to the Belgian, the Germans had visited Charleroi in order to study the Belgian glass industry and to introduce 'Belgian' production techniques in their country. Unfortunately, no technical details were mentioned. Moreover, despite the attested realisation of emerging German technological superiority, no further steps towards the transfer of new techniques from Germany to Belgium were taken.[995] Save for occasional instances, the *Association* remained largely indifferent towards the questions of technology and innovations for a long time.

At the session of 18th December November 1878, the president, Léon Mondron, communicated a letter to the members from a certain Mr Chardon, with the descriptions and plans of a 'new system applicable to melting furnaces, of English origin'. While the proceedings do not provide any technical information (neither has the letter itself been preserved), this can be regarded as the first instance when the *Association* acted as a forum for the exchange of technical knowledge. Yet, apparently, the instance remained without consequence, as no mention of this system was found in later proceedings or any other source. Moreover, it seems that the initiative did not originate from the *Association*. It would take some time before the organisation took an active role in 'knowledge management'.[996]

Slowly and reluctantly, the *Association* started to occupy itself with the questions of technology and innovation from the late 1870s on. The first instance upon which the

[993] Private archive Gobbe, Association, Originaux A, Requête au gouvernement provincial (no date, approximately 1848), Séance 11 septembre 1848, Séance 5 novembre 1849, Séance 8 janvier 1850
[994] Bracke, *Bronnen voor de industriële geschiedenis*, 222-224.
[995] Private archive Gobbe, Association, Originaux A, Séance 6 avril 1868
[996] Private archive Gobbe, Association, Brouillons I, Séance 18 décembre 1878

Association truly engaged, in depth, with the questions of technological innovation, applying its expertise for the thorough research and the evaluation of a new development, occurred in 1879. The issue concerned a new system for the improvement of the burning of coal in the melting furnaces' firebox, invented and patented previously, in England. As in the aforementioned cases, the *Association* did not take the initiative itself, as the plans were sent in by a certain Mr Chaudron in December 1878.[997] However, contrary to all previous cases, the *Association* decided to study the proposed invention in depth. This task was entrusted to Ch. Tock (of *verrerie de Mariemont*), who was respected for his technical expertise. About half a year later, in May 1879, Tock presented his report to the *Association*, which was then transcribed into the proceedings. As the report lacks drawings, the exact layout and functioning of the system is not entirely clear. The description as provided by Tock is as follows.

The device, that was called the 'Feeder Frisby', consisted of a sort of a funnel made of cast iron located under the firebox' grate. The funnel could turn around a horizontal axis, put in motion by a labourer though a system of intermediary gears. The system worked as follows. First, the funnel was filled with coal, before it was moved by a lever beneath a special hole that was made in the centre of the grate. Next, the funnel, which had a kind of 'movable bottom', became lifted together with the new load of coal that it carried. All these movements were conducted through a system of levers, put in motion by a labourer. With each lifting motion, the 'old' already burning coal, was uplifted and broken into smaller pieces, while a 'new' load of coal became deposited beneath the 'old' and deposited on the grid in a circular manner.

Despite some unclear details, the basic underlying idea and principle is rather straightforward. While in the traditional manner of work, the 'new' coal had to be added (literally thrown into the firebox) from above, the 'Feeder Frisby' allowed the addition of 'new' coal from beneath. The inventor claimed that this system could allow for slower and more 'complete' burning, resulting in more regular and 'intense' temperature. This would result in a noticeable economy of fuel.

These claims were examined by Tock. According to his report, within the traditional system, a certain quantity of cold air was allowed to enter into the firebox each time the door was opened to throw 'new' coal in. This lead to the loss of heat. Moreover, as the 'new' coal was being thrown above the 'old', a certain quantity of combustible products simply disappeared though the chimney without being burnt in the firebox. The 'Feeder Frisby' eliminated all of these causes of loss of heat, as the temperature within the firebox remained stable and the burning of coal proceeded in a regular, mostly uninterrupted way. Concluding, Tock stated that the use of the 'Feeder Frisby' enabled the saving of approximately 20% of fuel. Moreover, apparently, the system had already been applied successfully in multiple English factories.

In general, the application of the system could thus be recommended. However, it appeared that it was ill-suited to Belgian furnaces. The application of the 'Feeder Frisby' required a firebox of square, circular or oval shape at best. Yet in Belgium, rectangular fireboxes were

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[997] Private archive Gobbe, Association, Originaux C, Séance 23 décembre 1878

generally employed. In such fireboxes, the ‘Feeder Frisby’ could not distribute the coal evenly over the entire grate. In order to determine the technical possibility of deploying the ‘Feeder Frisby’ in furnaces of Belgian type, Tock had consulted a certain Mr J. M. Holmes, who owned the patent for the ‘Feeder Frisby’. From this consultation, it was concluded that the ‘Feeder Frisby’ could only be employed in oval fireboxes of 1,25 m (small axis) by 3,65 m (long axis). Given that most Belgian furnaces had a (rectangular) firebox of 3,15 m breadth, the adaptation for the employment of the ‘Feeder Frisby’ seemed impractical. Hence, despite acknowledging the advantages, Tock finally advised against the adoption of this innovation in Belgium.[998]

Despite the ultimately negative outcome of this case, it can be regarded as a true milestone or even a turning point with regard to the engagement of the *Association* with technology and innovation. While the initiative still originated from outside the *Association*, the *Association* decided to dedicate a whole ‘research programme’ to the study of this innovation. On another occasion, at the session of the 9th October 1885, president Fourcault communicated a letter to the members from a certain Mr Delmarmol, concerning his ‘system of window-glass production without blowing’. Although the members were encouraged to assist at the experiments conducted by Mr Delmarmol, no further notice of this invention is to be found in later proceedings or in any other sources, neither are any technical details known.[999] Apparently, the *Association* was still not interested in the development of new inventions, as opposed to the management of already-existing technology or adaptation of foreign inventions, as represented by the cases of Biévez-annealers and the ‘Feeder Frisby’ respectively. This situation would only change by the last years of the 19th century. Speculatively, it can be imagined that the Association regarded the mechanical production of glass as utopic, especially considering the important role of craftsmanship (see further).

However, the first signs of a reluctant turn towards a more active policy of the *Association* concerning innovations and dissemination of knowledge among its members, appeared only a few years later. During the session of the 4th April 1887, Mr. Gobbe (no first name mentioned) of the *Verrerie de Penchot*, Aveyron (southern France) delivered a lecture on his system of tank furnace. The *Association*’s records do not provide any technical details, mentioning only that the ‘lecture was interesting’. Nor is it known who (Mr. Gobbe or *Association*) took the initiative for this event.[1000] Be this as it may, this seems like the first instance whereby a foreign expert presented an innovation to the *Association*.

The *Association and mechanical glass production*

Technology for the mechanical production of window glass

As will be described in more detail in Chapter 3.3 on the innovation of the production process, the Belgian window-glass industry remained dependent on the manual shaping of material by means of glassblowing (the so-called cylinder method) until the First World War, despite many important innovations in the other stages of the production process. The only exception was the ‘mechanical’ factory of Fourcault, that replaced manual blowing with the

[998] Private archive Gobbe, Association, Originaux C, Séance 12 mai 1879
[999] Private archive Gobbe, Association, Brouillons II, Séance 9 octobre 1885
[1000] Private archive Gobbe, Association, Brouillons II, Séance 4 avril 1887

mechanical ‘drawing’ of glass (experimental production in 1906, normal production in 1912).[1001] Yet, despite the undeniably revolutionary character of Fourcault’s method, it only started to influence the organisation of industry after the First World War. Therefore, it will not be treated in much (technical) detail here. Nevertheless, as will be shown next, the *Association* was clearly interested in methods for the mechanical production of glass, a brief overview will be provided below.

<u>Lubbers process (mechanical blowing)</u>

The first mechanical process for the production of window glass was developed in the United States by John H. Lubbers. Starting in 1894, he developed a process whereby cylinders of glass were blown by using mechanically produced compressed air instead of human lungs. In this way, a much larger cylinder could be made at a faster pace. The cylinder still had to be cut and flattened manually. Lubbers acquired the first patent for this process in 1902. He succeeded in attracting the interest of the *American Window Glass Company* (further: AWGC°) from Jeanette, Pennsylvania, that represented 70% of the entire window glassmaking capacity of the United States at that time. The AWGC° started the commercial exploitation of the Lubbers method in 1904. This process became commercially successful in the United States quite quickly, contributing to the exclusion of Belgian glass from the American market. Outside the United States, the Lubbers process was adopted in the United Kingdom by *Pilkington* in 1909. However, this process had a fundamental flaw, as it produced glass of lesser quality due to wavy surfaces.[1002]

Interestingly, a similar process had already been patented in 1885 in Belgium, by Opperman, but it was not implemented.[1003]

<u>Flat sheet drawing (Colburn/Libbey-Owens and Fourcault)</u>

While the production of window glass by drawing of a flat sheet had been attempted from the late 19th century on by various inventors, success was only achieved by Colburn in the United States and Fourcault in Belgium shortly before or around the First World War. The basic principle consisted in the drawing of a continuous ribbon of glass directly from the bath of molten glass.[1004]

Irwing W. Colburn (1861-1917) of Massachusetts started experimenting with it in the early 20th century. In order to gather molten glass from the surface, a kind of a ‘bait’ was used by Colburn, consisting of a pair of rollers, called the drawbar, that gripped and pulled glass. Lacking financial resources, Colburn collaborated first with M. J. Owens, inventor of the first successful automatic bottle-making machine. Later, he engaged in a collaboration with the *Toledo Glass Company*. Finally, in 1916, the Libbey-Owens Sheet Glass Company was

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[1001] Thomas, “La société anonyme brevets Fourcault,” 224-229.
[1002] Cable, “The Development of Flat Glass Manufacturing Process,” 25-27; Barker, *The Glassmakers*, 213-214.
[1003] ARA-2, brevets, brevet nr. 69954 (1885)
[1004] Cable, “The Development of Flat Glass Manufacturing Process,” 27-30.

established, which commercialized the process. It is, therefore, known as the Colburn as well as the Libbey-Owens process.[1005]

Shortly before 1900, Émile Fourcault (1862-1919) of Charleroi[1006] started to collaborate with Emile Gobbe who had first conceived the process of glass-drawing, yet did not succeed in putting it in practice. Fourcault received a first invention patent for the glass-drawing process in 1901, followed by the 'improvement patent' (*brevet de perfectionnement*) in 1903. According to the literature, Fourcault did not succeed in getting the *Association* interested in this invention. Because of this, he had to search for support elsewhere, finally collaborating with Georges Despret, director of the plate glass company *Manufacture des glaces à Jeumont* (northern France, close to Belgian border). In 1905, *La société anonyme Brevets Fourcault* was established, thanks to capital from various Belgian and French plate glass manufacturers. In 1906, Fourcault carried out his first practical experiments. In 1912, he established *Verreries de Dampremy* near Charleroi as the first mechanical window-glass factory in Belgium. Still, the (financial) support for the enterprise did not come from the *Association*, but from German and Austro-Hungarian investors. The *Verreries de Dampremy* only started functioning in the spring of 1914. The 'key' of the Fourcault process was the *débiteuse*, a kind of a 'bait' shaped as a long narrow 'boat' made of refractory material with a longitudinal slot.[1007]

The *Association*'s involvement with the mechanical production of glass

The present literature is rather critical of the *Association*'s engagement with new technologies. It only briefly mentions a few contacts between the *Association* and the American Window Glass Company, that did not bear any practical results. Apart from this, it emphasizes the *Association*'s reluctance to support Fourcault, forcing him to search for support abroad, as described above.[1008]

However, from approximately 1900 on, the *Association* started to engage in a truly active policy related to technology and innovation, which can be described as a policy towards the promotion of technology transfer ('import' of technologies). The policy included the acquisition of information on the newest innovations (mostly related to the machines for the mechanical production of glass) from foreign countries by means of 'missions' abroad as well as the establishment of contacts with foreign inventors. Contrary to previous instances, in which technology transfer occurred by the means of personal initiative of individuals or individual firms (such as had been the case for the introduction of the tank furnace), the *Association* itself now behaved as an actor, providing incentives and organising exchanges. This increasing role of the *Association* as a collective actor can be attributed to the tightening of international competition, which made the role of technology ever more important. As

[1005] Ibidem, 28-30; R. W. Douglas and Susan Frank, *A history of glassmaking* (Henley-on-Thames: Foulis & C°, 1972), 154-156.

[1006] Although born in the Brussels commune of Saint-Josse-ten-Noode, he was a descendant of a glass manufacturer's family from the Charleroi region. He had spent most of his career in the region of Charleroi as well (Poty and Delaet, *Charleroi pays verrier*, 173-174).

[1007] Cable, "The Development of Flat Glass Manufacturing Process," 27; Thomas, "La société anonyme brevets Fourcault," 223-233.

[1008] Delaet, "La mécanisation de la verrerie à vitres à Charleroi," 115-116; Poty and Delaet, *Charleroi pays verrier*, 171-181.

already mentioned in the section on the quantitative analysis of patenting, the United States and Germany rose to prominence as the centres of innovation of the glass industry, while Belgium's own inventive activity started to lag behind. It is therefore not surprising, that these two countries (alongside the old competitor the United Kingdom) attracted most of the *Association*'s attention, as it was searching for innovations to 'import', as will be discussed in the following paragraphs.

In 1909, the *Association* decided that the 'machine question' needed to receive 'serious attention' from manufacturers and that the *Association* as a whole should engage in the study of this issue. In order to facilitate these studies, the *Association* decided to establish the special 'Fund for the study of Machines' (*Fonds pour l'étude des Machines*) that would cover the costs of travel and other expenses. At first, 'provisionally', the fund was fixed at 3,000 Belgian francs, to be financed by all members of the *Association*.[1009] The explicit mention of the 'machine question' points to the changing technological context, in which formalised knowledge, related to machines, increased in importance at the expense of more tacit and informal knowledge related to older manual production processes.

American glass-blowing machines

Somewhere in early 1903 (or already in 1902), the *Association* started to negotiate with the 'factories of Alexandria' in the United States on the possibility of a Belgian representative of the *Association* visiting the American factory in order to study a glass-blowing machine. No more details on the machine itself were provided, making it unclear whether the issue concerned the Libbey-Owens or not. Moreover, it is not clear which factories were meant exactly. Possibly, 'factories of Alexandria' referred to Alexandria in Virginia, which possessed multiple glass factories at the time. These factories seem to have specialised in bottles and hollow glass not in window glass, however.[1010] Be that as it may, the *Association* intended to send Oppermann to this American factory to study the functioning of the glass-blowing machine and to draw a report on the production cost and the quality of glass produced. However, the Americans had no intention of fully disclosing their production methods, only allowing Oppermann to study 'certain aspects'. Despite these limitations, the *Association* decided to authorise Oppermann's mission upon the final admission by Americans and to provide Oppermann with a subsidy of 5,000 Belgian francs to these ends. At the same time the *Association* expressed interest in another glass-making machine, which had been put into operation by a certain Sievert in Dresden.[1011]

Yet, one delicate matter about Oppermann's mission worried the *Association*. As Oppermann himself had been a patentee of a similar machine (already in the public domain by 1903), the *Association* feared that the Americans would accuse Belgians of industrial espionage if they

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[1009] Private archive Gobbe, Association, Originaux D, Assemblée Générale 29 mars 1909
[1010] Ted Pulliam, *Historic Alexandria: An illustrated History* (n. p.: Historical Publishing Network, 2011), 48-49; Char McCargo Bah, "The Other Alexandria: Working in the City's Glass Factories," The Connection to your community, published 5 February 2019, accessed 8 July 2022. http://www.connectionnewspapers.com/news/2019/feb/05/other-alexandria-working-citys-glass-factories/ ; City of Alexandria official website, "The History of Alexandria: Discovering the Decades," Updated 30 December 2021, accessed 08 July 2022. https://www.alexandriava.gov/historic-alexandria/basic-page/the-history-of-alexandria-discovering-the-decades
[1011] Private archive Gobbe, Association, Originaux D, Assemblée Générale 4 mai 1903

decided to introduce Oppermann's own machine after his mission. It was decided to consult a lawyer on this issue.[1012] The conditions, as communicated by the Americans by letter, raised doubts about the usefulness of Oppermann's mission among some members, as the Americans would allow him to report on 'some aspects' only, and not on the description of the machine. Nevertheless, the *Association* still hoped that Oppermann would be able to acquire exclusive information on the machine, as it mentioned explicitly that, if he were to 'discover secrets', he would communicate this information to the *Association* exclusively.[1013] On 10 August 1903, the *Association* discussed Oppermann's report, indicating that his mission had taken place despite all reservations. Unfortunately, the report itself has not been preserved. Yet, it can be stated that his mission was at least partially successful, as the Americans proposed to receive a Belgian delegation at their factories. Moreover, the AWGC° sent specimens of their glass for study by the *Association*.[1014] Subsequently, the *Association* decided to send delegates to America for further study and negotiations. Despite the opposition of a few members, who regarded the labour problem as more urgent, this proposition was adopted by majority vote.[1015]

Apparently, the *Association* was not the only one interested in the machine employed by the factories of Alexandria. As reported in an article from the National Glass Budget, which was discussed by the *Association*, Mr Pilkington himself (head of the British Pilkington glass company) had visited the Alexandria glass factories in order to study the glass-blowing machines in person.[1016] It is indeed known that Pilkington was in touch with Lubbers and the AWGC° from 1903 on already. However, the English manufacturer was reluctant to introduce this technology in England. This decision was taken in 1909 only, with several of Lubbers' machines being commissioned in England in 1910 and 1912. By that time, it was already clear that the quality of glass produced by this method would remain inferior to that of manually blown glass. As the literature puts is: 'There was no question, at this stage, of the machine-made glass driving the hand-blown product off the market, because the quality of the former was poor – Eastern Quality [clearly reminiscent of the 'Chinese quality', the lowest quality of Belgian glass for Chinese export] as it was called'.[1017]

Going back to Belgium, the 'American machines' (without further details) were discussed again in 1909, when it was mentioned that, apparently, these machines were used successfully and that (unnamed) inventors were willing to conduct tests in Europe in order not to let their patents expire.[1018]

The contacts with Americans resumed in February 1910, when a certain Mr Clack, engineer of AWGC° attended the *Association's* meeting, while he had already met some of the members shortly before upon the invitation of Mondron, one of the *Association's* prominent members. Mr Clack discussed the American method for the production of glass (which clearly referred to the Lubbers method, commercialised by the AWGC°) and answered

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[1012] Private archive Gobbe, Association, Originaux D, Assemblée Générale 22 mai 1903
[1013] Private archive Gobbe, Association, Originaux D, Assemblée Générale 8 juin 1903
[1014] Private archive Gobbe, Association, Originaux D, Assemblée Générale 10 août 1903
[1015] Private archive Gobbe, Association, Originaux D, Assemblée Générale 7 septembre 1903
[1016] Private archive Gobbe, Association, Originaux D, Assemblée Générale 26 juin 1903
[1017] Barker, *The Glassmakers*, 214-216.
[1018] Private archive Gobbe, Association, Originaux D, Assemblée Générale 29 mars 1909

various questions. Interestingly, the caption within the proceedings mentions the Empire Machine Company alongside the AWGC°. The relationship between these two firms is unclear, but it seems plausible that the former built and supplied the machines while the latter used them for the production of glass. The abstracts of both discussions with Mr Clack was kept in the special file on the mechanical production of glass. Unfortunately, this file has not been preserved. After the discussion, the *Association* decided that 'it would be extremely useful to send a delegation to America in order to study the machine of AWGC°'.[1019]

A few days later, Fourcault delivered a 'conference' (most probably, a lecture was meant) on the American process for the mechanical production of glass by machine-blowing, followed by a discussion on the price of glass that could be obtained if the American machines were used in Belgium. According to Fourcault, the price could not be lower than 1.50 Belgian francs per 100 pds (presumably *pieds* – (square) feet), to be increased with the royalties to pay for the patents, while, according to the opinion shared by the majority of members, the price of the present (manual) method could be lowered to 2.40 or even 2.20 Belgian francs per 100 pds in order to 'preserve the production of glass in this county [Belgium].'

The *Association* decided that it was of general interest to acquire and test an American machine at joint cost. However, further implementation was left to individual members without any obligation. Moreover, it was decided to send a Belgian mission to Pittsburgh in order to study the machine. Interestingly, the Association wanted to send this mission to Bilin first to study the Sievert machine, in all likelihood (although not stated explicitly) in order to be able to compare both systems. Interestingly, the *Association* wanted to ask the *Empire Machine Company* for permission to include one labourers' representative in the delegation. The total cost of this mission was estimated at 12,000 Belgian francs, to be paid by members of the *Association*.[1020]

And yet, despite almost unanimous interest in this innovation, the *Association* failed to compose the delegation due to the refusal of one key member to participate, more specifically the *Verreries Bennert & Bivort*, which informed the *Association* of its refusal by letter. While *Bennert & Bivort* admitted the utility of the American machine, the firm considered other measures for the defence of the general interests of the window-glass industry more urgent. Therefore, *Bennert & Bivort* refused to cooperate on the 'machine question'.

Reacting to this refusal, the *Association*'s president said 'It is deeply regrettable that an agreement could not be reached to take advantage of an exceptional occasion, offered to us to travel to the United States to visit foreign factories there, allowing us at the same time to study not only the process of mechanical production, but, moreover, to take account of the labour force conditions, of cost prices, and to stablish by ourselves the general conditions of powerful competitors, who operate on one of our important markets.'[1021]

[1019] Private archive Gobbe, Association, Originaux D, Assemblée Générale 14 février 1910
[1020] Private archive Gobbe, Association, Originaux D, Assemblée Générale 18 février 1910
[1021] Private archive Gobbe, Association, Originaux D, Assemblée Générale 4 avril 1910. Original quote: "Il est profondément regrettable que l'on n'ait pu se mettre d'accord pour mettre à profit l'occasion exceptionnelle qui nous était offerte de nous rendre aux Etats-Unis pour y visiter des usines étrangères et nous permettre en

Despite this setback, the *Association* remained in touch with the AWGC° and the *Empire Machine Company*, exchanging letters in order to be informed on the further developments of machines.[1022] After a technical study of this question and negotiations with Misters McMullin (or McMillin, unclear writing) and Monroe, representatives of the AWGC°, the *Association* decided that the introduction of an American machine would lead to 10 to 15% economy of coal when compared to manual production. The price of one machine was estimated at 1,000 dollars.[1023] By July 1910, the *Association* started to consider a new mission to Pittsburgh. This time, the *Association* concluded that the participation of two thirds of all manufacturers would suffice to organise the mission.[1024] There is no evidence, however, that the mission was ever organised.

About one year later, McMullin and Monroe visited Belgium again, conducting negotiations with the *Association*. While no technical details were recorded, the proceedings still speak of 'mechanical blowing' (*soufflage mécanique*), indicating that the American machine in question was still of the blowing type, as opposed to the glass-drawing machine of Fourcault. Addressing the *Association*, McMullin said that Belgium remained the only country with which negotiations had failed so far, while Russia, Germany, France, Italy, and England (*Pilkington*) had already successfully concluded negotiations with the AWGC°, introducing machines in their factories. After McMullin, Monroe took the floor. After a long discussion, he encouraged Belgians one more time to send a delegation to the United States, assuring that nothing would be hidden, and that the delegates would receive all the information they wished.

It seems that the AWGC° was quite interested in Belgium as well, as it proposed preferential treatment. Monroe declared that the AWGC° would promise not to sale machines to Japan, Korea and China if an agreement with the Belgians were reached. The *Association* unanimously decided to study further the propositions made by the AWGC°. Interestingly, Fourcault attended this meeting as well, even though he was developing his own system at that time, and thus regarded the AWGC° as competitors.[1025]

At the next *Association* meeting dedicated to the American machine, Fourcault delivered 'an extremely interesting lecture' on the American method of the mechanical production of glass. His conclusion was rather negative, as he judged that losses due to *pochage* (meaning of the term unclear) would be considerable. Nevertheless, the *Association* decided that it would be 'extremely useful' to study the working of machines in German factories where they were already employed, and, moreover, to send a delegation of Belgian manufacturers to Pittsburgh. Interestingly, Fourcault did not propose his own system as an alternative. Moreover, he decided to abstain from further examination of the situation as it appeared to

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même temps d'étudier non seulement les procédés de fabrication mécanique, mais encore de nous rendre compte des conditions de la main d'œuvre, du prix de revient et de constater par nous-mêmes les conditions générales dans lesquelles se trouvent des concurrents puissants, opérant sur un de nos importants marches"

[1022] Private archive Gobbe, Association, Originaux D, Assemblée Générale 9 mai 1910; Assemblée Générale 13 juin 1910

[1023] Private archive Gobbe, Association, Originaux D, Assemblée Générale 1 juillet 1910

[1024] Private archive Gobbe, Association, Originaux D, Assemblée Générale 8 juillet 1910

[1025] Private archive Gobbe, Association, Originaux D, Assemblée Générale 27 juillet 1911 him ‘too delicate’ because he possessed his own invention patents for an alternative technology.[1026]

Still, the *Association* regarded Fourcault as the most technically competent member, as it appears from the discussions on the composition of a delegation to be sent to the United States to study the AWGC° machine. Fourcault was proposed in the first instance, yet he declined due to his ‘special and personal reasons’. However, he agreed to go to Germany to study the functioning of machines at the factory of Müllensiefen brothers in Crengeldanz. The delegation for the United States was ultimately composed of Julien Schmidt and the *Association* secretary Van der Elst. They visited the factories of the AWGC° in Pittsburgh between 21 October and 22 November 1911. The results of these missions were discussed during two special sessions in December 1911. Unfortunately, the proceedings of these sessions were kept in a separate file, which has not been preserved.[1027]

The aforementioned Müllensiefen in Crengeldanz (part of the city of Witten in North Rhine-Westphalia) was an important glass factory, founded in 1825 by brothers Gustav (1799-1874) and Theodor (1802-1879) Müllensiefen. It appears that Fourcault had good contacts with this factory in the early 20th century, which eventually resulted in the introduction of Fourcault machines in this factory. Hence, Fourcault’s role appears quite dubious in this respect. While he had been sent by the *Association* officially to study the machines of the AWGC° that had already been employed by this factory at that moment, he negotiated for the introduction of his own machines at the same time, which seems like nothing less than a conflict of interest. At the same time, this instance shows that Fourcault operated on his own behalf, without the assistance of the *Association* despite being one of its members.[1028]

In January 1912, the *Association* decided to send a delegation of the representatives of all member firms to the Müllensiefen factory in Crengeldanz to study the working of the machine of the AWGC°.[1029] Further negotiations with the representatives of the AWGC° took place on 15 July and 9 August 1912. The results were kept in a special file, which has not been preserved.[1030] This was the last mention of the AWGC° machine in the proceedings.

The English machine of Forster & Sons

The *Association* did not limit its active efforts towards the study and possible acquisition of new technologies for the benefit of all its members to the United States alone. In 1908, it initiated negotiations with *Forster & Sons* of Saint Helens (England), inventors of a glass-blowing machine. This is somewhat puzzling, given that this firm, to our knowledge, specialised in bottles (as well as machines for bottle-making) and not in the production of

[1026] Private archive Gobbe, Association, Originaux D, Assemblée Générale 31 juillet 1911
[1027] Private archive Gobbe, Association, Originaux D, Assemblée Générale 11 août 1911; Assemblée Générale 29 décembre 1911
[1028] Wittener Stadtgeschichte. “ZUR HUNDERTJAHRFEIER DER FIRMA GEBR. MÜLLENSIEFEN GLASFABRIK CRENGELDANZ WITTEN 1825-1925.” Accessed 25 July 2022. https://web.archive.org/web/20070927015006/http://www.annen-city.de/muellsi1.htm
[1029] Private archive Gobbe, Association, Originaux D, Assemblée Générale 19 janvier 1912
[1030] Private archive Gobbe, Association, Originaux D, Machines A.W.G.C° Empire C° (undated note, inscribed between the Assemblée Générale du 20 mai 1912 and Assemblée Générale du 4 octobre 1912)

window glass.[1031] However, as the firm was located in Saint Helens, a primary centre of the British glass industry including window glass (*Pilkington*), it is plausible that it intended to diversify and develop equipment for other branches of the glass industry as well. Be that as it may, it appears that *Forster & Sons* already had functioning glass-blowing machines by 1908, as it invited a delegation of the *Association* to observe the working of the machines.[1032] Reacting to this, the *Association* sent a commission consisting of P. Noblet, Chausteur and Paul Lambert to Saint Helens on 4 January 1909.[1033] The results of this mission were discussed in February and March. Unfortunately, the report itself was not preserved. Yet, the *Association's* proceedings provide us with some information. It appears that a machine of Foster & Sons was already functioning at the *Pilkington* factory.[1034] After lengthy discussions, the *Association* decided that the machine of *Forster & Sons* was interesting, and that it could be useful to conduct trials with it. However, the question of invention patents and other conditions and legal issues would have to be resolved beforehand.[1035] In March 1909, a certain Delacuvellerie informed the *Association* on the 'improvement of his inventions, applied to a (glass) blowing machine in the style of the 'Pilkington-Forster' machine. The *Association* reacted by stating that it was studying different systems.[1036] Yet, surprisingly, the extensive monograph on the history of the Pilkington company by T.S. Barker does not mention any machine by Forster.

By late April 1909, the *Association* resumed negotiations with Forster himself. First, on 25 August, three representatives of the *Association* (Noblet, Goffe and secretary) met with Forster in Brussels. On 27 August, Forster attended the *Association's* meeting personally. The negotiations were based on a report drawn up previously by the *Association*. Despite not being preserved, it appears that while the report contained some (unspecified) objections, the general conclusions must have been at least partly positive, as further negotiations between the *Association* and Forster considered the conditions of practical trials of machines in Belgium. According to conditions, Forster would deliver four complete machines to the port of Antwerp, while the *Association* would finance the unloading, customs, transport to the factories as well as installation, air compressors needed for the machines, and the labourers' wages. If the test proved satisfactory, the *Association* would have an opportunity to acquire machines, with the standard price set at 1,000 pounds. The price of invention patents for the machines was set at 20,000 pounds if acquired before 1 October 1909, and 25,000 pounds if acquired between 1 October 1909 and 21 December 1909.

The exact subject of negotiations between Forster and the *Association* is not entirely clear. It seems nevertheless that Forster wanted to demonstrate the practical applicability of his machine in the first place. After this, the conditions for the acquisition of technology came to the fore. The remarks on the prices for the acquisition of patents implies that 'acquiring

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[1031] The National Archives (United Kingdom), "Catalogue description: FORSTER'S GLASS CO. LTD; ST. HELENS, LANCASHIRE," accessed 14 July 2022. https://discovery.nationalarchives.gov.uk/details/r/2402361f-2949-46c4-ac03-50b999a3e0fb ; "Grace's Guide To British Industrial History, "Forster and Sons," accessed 14 July 2022. https://www.gracesguide.co.uk/Forster_and_Sons

[1032] Private archive Gobbe, Association, Originaux D, Assemblée Générale 21 décembre 1908

[1033] Private archive Gobbe, Association, Originaux D, Assemblée Générale 26 décembre 1908

[1034] Private archive Gobbe, Association, Originaux D, Assemblée Générale 1 février 1909

[1035] Private archive Gobbe, Association, Originaux D, Assemblée Générale 29 mars 1909

[1036] Private archive Gobbe, Association, Originaux D, Assemblée Générale 29 mars 1909 knowledge' (in this case, in the form of invention patents) was at least as important (if not more important) than acquiring physical machines.

During the discussion, Forster (unsurprisingly) refuted the (unspecified) objections formulated in the *Association's* report, while emphasising the advantages of his machine. The main advantage was the possibility to employ less-skilled workers. Forster stated that 'starting with skilled workers, it would be possible to replace them gradually with lower-paid workers that could be trained rapidly.'[1037] Hence, de-skilling of the workforce featured explicitly as a key advantage of the new technology. By way of illustration, Forster mentioned the example of his machines being installed in China, upon which most English workers returned home, while the machine was operated by a team consisting of two Chinese (implicitly less skilled) and one English worker. The importance of skills will be discussed in the next chapter.

Nevertheless, Forster admitted that it was difficult to retrofit the glass-melting furnaces used in Belgium with his machines, suggesting the installation of the machines simultaneously with the reparation of furnaces.[1038] The exact reason why Forster's machine did not fit Belgian furnaces was not provided.

Therefore, despite the advanced state of negotiations, the *Association* eventually decided not to accept Forster's offer, as it judged the price he demanded for his machines to be too high when weighed up against the economies that could be made if tests proved successful. Moreover, it appears from the formulation used (*l'hypothèse d'un essai satisfaisant*) that the tests had not taken place.[1039] After 1909, no further contacts with Forster were recorded.

The German machine of Sievert

As already mentioned, the *Association* conducted negotiations with a German inventor from Dresden called Sievert from 1903 on. Unfortunately, no technical details on Sievert's machine could be found, not even about the most basic principles. Yet it is known that Paul T. Sievert of Dresden was experimenting with compressed air for the production of hollow glass shortly after 1900.[1040] Therefore, it is plausible that his machine for the production of window glass was based on the mechanical blowing of cylinders similar to the Lubbers process.

It appears that the negotiations with Sievert were conducted by the *Association*'s President, the Secretary, and one member. According to their words, Sievert had travelled to the United

[1037] Private archive Gobbe, Association, Originaux D, Assemblée Générale 27 août 1909, Quote: "En utilisant au début des ouvriers habiles, on peut arriver progressivement à les remplacer par des ouvriers à salaire moins élevé qui seraient rapidement formés"

[1038] Private archive Gobbe, Association, Originaux D, Assemblée Générale 27 août 1909, Quote: "[Foster] tout en reconnaissant que les dispositions actuelles de nos fours devaient subir d'importantes modifications qu'il [Foster] suggère d'effectuer au fur et à mesure de l'installation des machines, pendant la période des réparations"

[1039] Private archive Gobbe, Association, Originaux D, Assemblée Générale 10 mai 1909; Assemblée Générale 24 mai 1909

[1040] "A New Means of Using Compressed Air in the Manufacture of Glassware," *Scientific American* 86, no. 19 (10 May 1902): 329; "The Sievert Process of Mechanical Glass Blowing," *Scientific American* 89, no. 14 (3 October 1903): 336.

States hoping to observe the working of a glass-blowing machine in person, yet to no avail, as he could not observe the functioning of the machine, nor study its products. Apparently, the American glass-blowing machine attracted much attention from foreign countries (Belgium, United Kingdom, France) at that time, while the Americans themselves were reluctant to disclose their knowledge to outsiders in this respect. Yet Sievert was not discouraged by this refusal, as, apparently, he had already been experimenting with his own glass-making machines, and he wished to invite Belgian manufacturers to come and take notice note of the results 'he was aspiring to achieve'.[1041]

After a few years of silence, the Sievert machine appeared again in the proceedings in 1909, when Léon Mondron, one of the *Association's* members, informed the *Association* about the patents relating to the mechanical production of glass that had been offered to him on condition of a monopoly for Belgium by a 'German firm' (probably Sievert himself, as this announcement is recorded under the caption 'machine Sievert'). Léon Mondron presented the offers transmitted by the 'German firm' and proposed forming a mission to study this process in Austria.[1042]

The negotiations with Sievert were pursued further simultaneously with Forster, as, apparently, the *Association* wished to explore multiple alternatives. During the meeting of 29 August 1909, the *Association* discussed an invitation (most probably from Sievert himself) to visit Sievert's 'installation' in 'Billin' where these machines were already functioning. Responding to this proposal, the *Association* decided to send a delegation. At the same time, H. Lambert remarked that (unspecified) German manufacturers had already acquired Sievert's patents, and had already put his machines in operation a month or so previously.[1043] This 'Billin' (consistently spelled with double 'll' in the proceedings), was most probably Bilin in Austria as it was then, now Bílina in the Czech Republic. This spa town possessed two glass factories in the late 19th century (the Engels factory and the Adlerhütten factory), although only the production of hollow glass and bottles there is mentioned explicitly.[1044]

In June 1909, the delegation presented its report (not preserved) on Sievert's machine upon the return from Bilin. The subsequent discussion resulted in the conclusion that this production technique did not interest Belgian industry at that moment, although the *Association* wished to stay in contact with Sievert to be informed on his progress, and decided to keep this option open. On the same occasion, the delegation informed the *Association* about the state of the glass market and industry in Austria.[1045]

In late 1909, F. Lambert, who had visited Sievert in Dresden previously, informed the *Association* that the machine functioned satisfactorily, and mentioned the 'serious progress' made by Sievert. Reacting to this, one of the *Association's* members stated that '[i]t is essential to keep abreast of what is happening, because the progress of 'machinism' seems

[1041] Private archive Gobbe, Association, Originaux D, Assemblée Générale 10 juillet 1903
[1042] Private archive Gobbe, Association, Originaux D, Assemblée Générale 29 mars 1909
[1043] Private archive Gobbe, Association, Originaux D, Assemblée Générale 27 avril 1909
[1044] Turistický a informační portál Bílina, "Historie města," accessed 18 July 2022. https://www.icbilina.cz/cs/pruvodce-mestem/historie-mesta.html
[1045] Private archive Gobbe, Association, Originaux D, Assemblée Générale 18 juin 1909

to be rapid.'[1046] Hence, there was a clear sense of urgency within the *Association* not to lag behind technologically.

In early 1910, the *Association* received information on the implementation of Sievert machines at a 'Saxonian factory in Brand' (*Usine de Saxe, à Brand*, the exact location could not be established). However, the owners of this factory did not allow the *Association*'s representatives to visit the factory. On the other hand, Sievert himself offered to visit his factory in Bilin, where he was willing to show the latest improvements of his machine. The *Association* decided to send a new delegation to Bilin.[1047] No further mention of this mission, or of Sievert's machine was recorded in the proceedings thereafter.

Other machines

While the American glass-blowing machine attracted most of the *Association's* attention shortly after 1900, other potential sources of innovation were actively explored as well. In July 1903, the *Association* invited Hanappe, Rowant and Francq to discuss their method for the production of window glass. Unfortunately, the proceedings do not provide many details on the principles of this invention, except for a rather vague phrase that '[t]he construction [of the machine] is based on the principle of the 'cylindrifying' of sheet glass, in a device that shelters the molten material from atmospheric influence.'[1048] At any rate, the *Association* clearly showed interest in this invention, at least initially, as it decided to form a special commission to study it in depth.[1049]

While foreign (mostly American) machines attracted most of the *Association's* attention, Belgian developments were almost totally absent, with one exception. In 1907, André-Marie Oppermann described to the *Association* a new kind of mechanical glass production invented recently by his son, Fritz Oppermann. Interestingly, the process was described as 'drawing' (*étirage*) rather than blowing. Unfortunately, any further technical details are lacking. While the *Association* showed some interest in the system initially, the question never appeared in the proceedings again.[1050] The Belgian machine of Fourcault was mentioned only once in 1910, when the *Association* engaged in negotiations with Fourcault concerning his invention patents.[1051]

Conclusion

It can be concluded that the public-disclosure strategy was largely absent in Belgium, contrary to France. The *Association* did not take initiative for the dissemination of knowledge

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[1046] Private archive Gobbe, Association, Originaux D, Assemblée Générale 13 décembre 1909. Quote : "Il est indispensable de se tenir au courant de ce qui s'accomplit, car le progrès du machinisme paraissait devoir être rapide"
[1047] Private archive Gobbe, Association, Originaux D, Assemblée Générale 4 février 1910
[1048] Private archive Gobbe, Association, Originaux D, Assemblée Générale 3 juillet 1903, Quote : "la construction est basée sur le principe du cylindrage du verre en feuille, dans un dispositif mettant la matière en fusion à l'abri de l'influence atmosphérique"
[1049] Private archive Gobbe, Association, Originaux D, Assemblée Générale 26 juin 1903, Assemblée Générale 3 juillet 1903
[1050] Private archive Gobbe, Association, Originaux D, Assemblée Générale 8 juillet 1907
[1051] Private archive Gobbe, Association, Originaux D, Assemblée Générale 4 avril 1910

by means of publications or other channels, neither are we aware of similar initiatives originating from outside the *Association*. The situation only started to change in the last years of the 19th and early 20th centuries, mostly thanks to one person, Emile Fourcault, who wrote the first (yet, unpublished) treatise and taught a specialised course at the University of Labour. The first specialised trade journal, dedicated to the glass industry (the aforementioned *Industrie du Verre*) did not appear until the eve of the First World War, while some other industries had already had trade journals since the 1870s and 1880s.

It is difficult to estimate the degree of secrecy and disclosure within the community (or communities if we regard the labourers and the manufacturers as distinct communities). It seems highly likely (indeed, almost certain) that some informal sharing of information occurred within the community of manufacturers (as represented by the *Association*), as exemplified by the aforementioned remark concerning Casimir Lambert, who was willing to share knowledge with his fellow manufacturers. However, the reluctance to share information with outsiders, as suggested by the lack of published treatises, is quite evident as well. As for the labourers, the informal sharing of knowledge must have been inseparable from the learning that was conducted in informal ways until the early 20th century.

The notebooks discussed in the context of chemical knowledge (glass composition) provide us with intriguing evidence of informal knowledge-management on the individual level. They might have been used to keep personal knowledge (‘secrets of trade’ or even ‘tips and tricks’) secret, but they could serve for the sharing of knowledge as well, and be copied. Moreover, the social background of their owners is unknown, save for the engineer Oppermann, who, while not being a manufacturer himself, was certainly socially closer to manufacturers than to labourers. The situation is unclear for the two anonymous notebooks. They might have belonged to foremen, to be situated in the middle ground between labourers and manufacturers. Yet this is nothing more than an educated guess.

As for other knowledge-management strategies, no traces of collective-invention mechanisms were found. This is rather surprising, as this strategy is often considered typical for industrial-district settings. Two considerations argue against the collective-invention strategy (as an intentional process) in the Charleroi region. First, there were no formal open channels for systematic information exchange, such as trade journals, until the early 20th century. Secondly, the members of the community were often protective of their knowledge, as is attested by the aforementioned high propensity to patent, including ‘trivial’ inventions.

This does not mean that other knowledge-sharing mechanisms between various enterprises within the Charleroi industrial district were totally absent. For instance, the aforementioned case of Casimir Lambert can be recalled. It is possible (indeed, highly likely) that knowledge was shared and exchanged within the community in other ways, less systematic and even less intentional. Yet the source situation does not allow us to investigate this further.

Despite the lack of a collective-invention regime, other strategies for the collective management of knowledge and know-how appeared, as the *Association* started to implement a systematic policy towards technological innovation after 1900. This coincides with a sharp decline in inventive activity in Belgium itself, which is apparent from the analysis of invention patents after the 1880s. While no connection between these two tendencies was mentioned explicitly in the proceedings or any other source, some kind of a causal connection seems possible. It seems plausible that, given that the old way of doing things (that is, developing innovations on an individual basis, yet with possible use of informal and even unintentional information-sharing within the community as well) started to fail, as the Belgian window-glass industry began to lag behind foreign competitors with respect to technology, the *Association* decided to start a collective effort towards technological innovation. This lagging behind foreign competitors is apparent from the remark that the 'machine question' required 'serious attention', expressed during the *Association's* general assembly in 1909. From the perspective of the 'New Industrial District' approach of Michael E. Porter, the actions undertaken by the *Association* can be clearly defined as 'pipelines', that is, as conscious efforts to establish connections between the district and outside partners. This indicates that the functioning of the district entered a new phase, more in line with the 'new industrial districts' of the late 20th century when compared with the 'classical' Marshallian districts. To recall the theory, the 'New Industrial District' approach of Porter and followers puts the emphasis on the role of knowledge exchange between the district and the outside world (the 'pipelines'). This complements the knowledge exchange on the local level ('buzz'), which was already acknowledged by Marshall in the original theory as the 'industrial atmosphere'. According to Porter, the establishment of 'pipelines' is almost never automatic, as such long-distance exchange channels require conscious effort for their establishment and maintenance. In fact, the first 'pipelines' were already established by the *Association* back in the 1860s for the exchange of commercial information (contacts with the English Association of glass masters, see Part 2 Chapter 2.2). Yet, it was only from approximately 1900 onwards that the Association started to employ 'pipelines' for the exchange of information on technology. Moreover, our case presents an interesting addition to the New Industrial District' approach. While Porter considered only the role of individual firms for the establishment of 'pipelines', my research attests that the business interest organisations, such as the *Association*, were capable of this task as well.

However, it is striking that these efforts were directed towards the facilitation of technology transfer without any recorded efforts towards the stimulation of research and development in their own midst. Remarkably, the development of mechanical glass production by Émile Fourcault was almost never mentioned in the proceedings despite the fact the Fourcault was a prominent member of the *Association* himself. Moreover, his technological expertise must have been acknowledged by the *Association*, as he acted as an expert for the assessment of promising foreign technologies on multiple occasions. Here, the difference with the collective-invention mechanism can be emphasised again. While the collective-invention mechanism presupposes incremental improvements in technology by participants themselves, assisted by publications of information in a largely 'open' way, the actions of the *Association* aimed at the acquisition of already-existing foreign technology. Here, the information-sharing occurred at the *Association* assemblies. While, presumably, information was accessible to all *Association* members, the information regime was certainly more 'closed' than open publication, as presupposed by the collective-invention theory. Yet, both instances can be regarded as cases of collective knowledge-management, it can be concluded that such management could take various forms.

As mentioned above, the existing literature gives a negative image of the *Association'*s involvement in the development as well as appropriation of new technologies, 'blaming' it for the lack of support given to Fourcault, who had to turn to the representatives of other branches of the glass industry (plate glass) as well as to foreign investors in order to find (financial) support for the further development and commercialisation of his invention. Moreover, if we are to believe the existing literature, the *Association* showed only limited and occasional interest in new foreign technologies as well.[1052]

However, as is made clear by the aforementioned cases (the American machine of Lubbers/AWGC°, the English machine of Forster and the German machine of Sievert), the *Association* engaged quite actively in the research of new technologies, as is apparent from the organisation of negotiations with foreign inventors, the missions to study foreign machines abroad and the establishment of the Fund for the study of Machines. And yet, despite this active engagement, none of the new foreign machines was ever introduced in Belgium. It is impossible to know for sure why the *Association* never implemented the machine of the AWGC° or any other foreign inventor, as no explicit motivation has ever been recorded. This seems rather surprising indeed, as we now know how much effort the *Association* dedicated to the study of this system and to negotiations with the Americans.

On one occasion in 1910, the attempt to introduce the American machine of the AWGC° failed due to the refusal to cooperate by one key member, *Bennert & Bivort*. While this occurrence cannot explain the failure to introduce the new technology in all cases such as those of Sievert or Forster & Sons it is of more than just anecdotal interest. If anything, it illustrates the paradoxical position of the entire industrial district (and the community that made it) by the early 20th century.

On the one hand, an urge to cooperate more was clearly felt, as it had become clear that the 'old ways' that had served the district so well for so long, were starting to fail it. Two new challenges needed to be addressed: the rise of the labour movement (see chapter on the production process), and the emerging technological backwardness. Important efforts were undertaken by the *Association*, which acted as the main governing body with the industrial district, to address both issues. The measures taken by the *Association* in the area of technology transfer were truly remarkable. And yet, at least in this instance, the individualistic attitude of one firm led to failure, making it clear how the inability to arrive at a truly unified organisational policy directly led to the failure to adapt a new technology. This case makes a fine illustration of Porter's New Industrial District model, whereby local 'buzz', facilitated by geographical proximity, interacts with global 'pipelines'. This illustration is 'negative', however, as it shows how the inability to establish effective local cooperation led to the failing of pipelines. Hence, at least in this particular case, the lack of solidarity of even one (yet prominent) member could undermine solidarity, showing the limits of collective agency. The same firm, *Bennert & Bivort*, showed 'dissident behaviour' in other contexts as well, as discussed in Part 2, in the section on the internal cohesion of the *Association*.

A report on the state of the Belgian window-glass industry in 1913 provides another reason for not adopting foreign technology, as it mentions the 'very interesting results' achieved by Fourcault in the mechanical production of glass. Moreover, the report states quite explicitly that: 'If the mechanical production of glass should be realised, it would be highly desirable to

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[1052] Delaet, "La mécanisation de la verrerie à vitres à Charleroi," 115-116; Poty and Delaet, *Charleroi pays verrier*, 171-181.

occur in Belgium, by Belgians and for Belgians; it's the only means for our specialists of glass to secure future over other peoples and to preserve with us an industry, in which we are particularly specialised.'[1053]

It appears, therefore, that the *Association* preferred the Fourcault system, which was developed to the practical stage by then.[1054] This system, which relied on glass-drawing rather than glass-blowing such as was the case for the American, English (Forster & Sons) and, presumably, German (Sievert) machines, was certainly superior technologically. The glass-drawing systems (Colburn/Libbey-Owens and Fourcault) rapidly replaced all other techniques (such as manual and mechanical blowing) after the First World War.[1055] Regarded in this way, the decision not to employ American, English or German glass-blowing machines was a wise one, at least in hindsight (around 1900, the Fourcault system was still in its experimental stage). Yet, the *Association* played no part in the development of this system. Paradoxical as it may seem, the development of a new process by Fourcault can be seen as a triumph of the old way of the individualistic approach to innovations (that is, on an individual basis within a single firm). Yet, this 'individualistic action' proved to be more successful than the new way (collective policy towards the adoption of innovations) as attempted by the *Association* in the last decades before the First World War. It can therefore be stated that, despite all efforts, the *Association* as the main governing body of the industrial district failed in adapting itself to the new circumstances at the beginning of the 20th century, despite all efforts. At least partly, this failure can be attributed to the individualistic attitude and agency of some firms, such as *Bennert & Bivort*, the same individualistic attitude that prevented closer commercial collaboration between the member firms, as described elsewhere. It seems that by the early 20th century, the *Association* strove towards more collective action, acting against the old individualist attitudes. Yet, despite all efforts on the *Association*'s part, opposition by even one 'dissident', such as *Bennert & Bivort*, was enough to undermine collective action.

The role of Fourcault is not entirely clear either. It is known that he was the *Association*'s president between 1895 and 1902,[1056] and remained an active member afterwards. In fact, as mentioned, his expertise was often requested by the *Association* in the context of the glass-blowing machines. If he was developing his own glass-drawing machine at the same time, this would have represented a conflict of interest. Yet, there isn't any hard proof that Fourcault would have tried to prevent the introduction of other (foreign) machines in order to favour his own invention. The fact that the *Association* trusted him in these matters rather suggests that he was regarded as impartial by other members. Due to the lack of any explicit evidence this remains just a guess, however.

[1053] Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913 (inscribed between Assemblée Générale du 9 février 1914 and Assemblée Générale du 18 décembre 1914), Quote : "Si la fabrication mécanique du verre doit se réaliser, il est hautement souhaitable qu'elle voit en Belgique et par des Belges et pour des Belges; c'est le seul moyen que ont nos spécialistes du verre de conserver l'avenir sur les autres peoples et maintenir chez nous une industrie par laquelle nous nous sommes particulièrement spécialisées"
[1054] Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l'Exercise 1913
[1055] Cable, "The Development of Flat Glass Manufacturing Process," 30; Barker, *The Glassmakers*, 213-214.
[1056] Poty and Delaet, *Charleroi pays verrier*, 174.

In conclusion, the second research question can be answered as follows. Of all the knowledge-management strategies, patenting was the most prominent. Being an 'individual' strategy (individual agency of an inventor or a firm), the prominence of this strategy attests to the prevalence of individualistic attitudes within the district, despite some evidence of informal information-sharing (disclosure). The popularity of patenting was certainly stimulated by the favourable legal context resulting in the low threshold to patent. Patenting remained the preferred strategy during the period up to 1870, approximately. This was the 'golden age', when the position of the Belgian window-glass industry on the global market was almost uncontested. The collective strategies only emerged after 1880 and, more prominently, after 1900, albeit not along the lines of the 'classical' collective-invention model, as no public sharing of information via publications occurred. They were instead represented by the *Association*'s efforts to acquire knowhow from abroad (with the *Association* representing collective agency). Here, the *Association* strove for the collective management of some types of knowledge (namely, know-how related to the latest developments of mechanical glass production) in order for the entire community (members of the *Association*) to advance collectively. The *Association*'s goal was to acquire knowledge from abroad, not to develop it themselves. This development can be related to two factors. First, the general position of the Belgian window-glass industry on the global market became more challenging due to the developments in other countries, such as the United States and Germany. Second, the character of technology and innovation itself started to change, moving from more 'practical' and even 'tacit' to more 'scientific' or at least 'formalised' (see also the following chapter). Hence, the changing circumstances after 1880 (international competition and technological developments) stimulated members of the community, as represented by the *Association*, to partly abandon their individualistic attitudes in order to face the new challenges. Yet the actions of 'dissidents' such as *Bennert & Bivort*, while being exceptional, showed the limits of this collective agency. Hence, individual agency continued to be decisive, or at least the individual agency of a large and important firm.

Chapter 3.3: The development of technology and its relationship with craftsmanship

While the previous chapters concentrated on the way in which the knowledge related to technology and innovation was managed within the glass-making community of the industrial regions of Charleroi and, partly, the Centre, this chapter will explore the way in which these innovations have effectively been developed and put into practice. But first, some theoretical and historiographical concepts for the analysis of technological developments will be presented.

Theoretical and historiographical concepts for the study of technological development

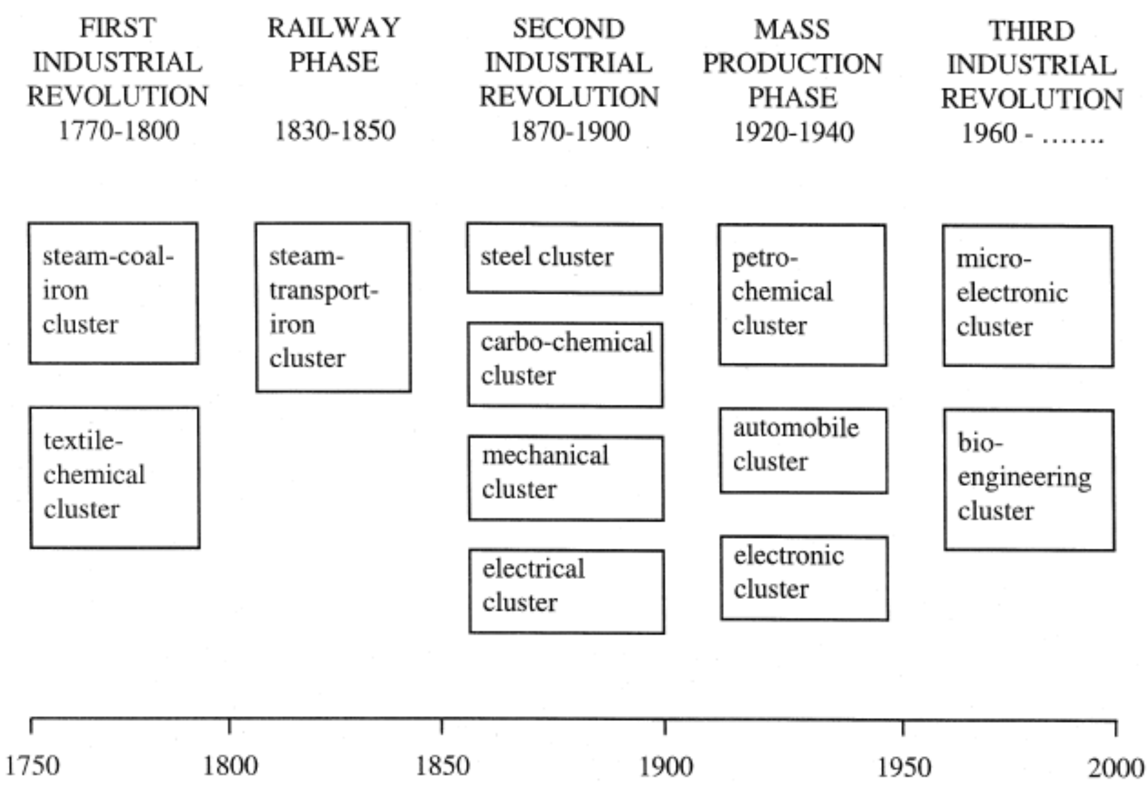
Clusters of innovative industries

The development of every specific technology is interlinked with other technologies in many ways. At the same time, viewed over a longer term, technologies do not develop in a linear way, but instead follow a development path consisting of distinct successive stages. Hence, to fully understand how one specific technology developed over time, it is necessary to contextualise its connections to other technologies, as they followed their life cycles.

A relevant framework for such an analysis is provided by Ron A. Boschma, who introduced the concept of clusters of innovative industries. Each cluster represents a group of industries that are connected by strong techno-economic linkages. Such clusters are grouped within a number of techno-industrial stages. As these stages follow each other in chronological manner, the whole scheme represents a model of long-term technological development. Therefore, it is useful as a 'tool' for the analysis of the industry (such as the window-glass industry) in the long run, showing possible interlinkages with other industries.[1057]

The scheme as presented by Boschma identifies 12 clusters, grouped within five stages between the onset of the Industrial Revolution around 1750 and the 'present time' (1999), as can be seen on the Figure 10. The scheme is based on Belgian empirical material.

Figure 10: Clusters of innovative industries



Source: Boschma, "The rise of innovative industries in Belgium," 857.

Some observations on this representation can be made. While the representation seems reasonable for the period up to the First World War, for the 20th century, the absence of aerospace and nuclear clusters is rather surprising.

In the Boschma model, each cluster is typified by strong techno-economic linkages between various industries. This is based on the assumption that inventions and innovations, for the most part, are a result of interaction and cooperation between various actors, rather than independent actions. Industries develop a network configuration of linkages and

[1057] Boschma, "The rise of innovative industries in Belgium."

interdependencies of various kinds, which assure transfer of innovations between industries. The scheme as presented by Boschma distinguishes four mechanisms in such a transfer.

First, the *producer-user relationship mechanism* refers to the fact that new key inputs, such as energy sources, components and materials, can open new opportunities in a range of industries. For example, the development of a practical electric motor in the late 19th century allowed for the mechanisation of small-scale industries, where the application of steam power was impractical, thus engendering a profound reorganisation of many industries.

Second, the *production-system interdependency* mechanism refers to the fact that innovations within one stage of a production process can stimulate and engender innovations in other parts. The classic example of this mechanism is the development of the textile industry, whereby the introduction of new spinning machines in the late 18th century stimulated innovations in other production stages, such as weaving, carding, bleaching and so forth.

Third, the *technological complementarity* or *inter-relatedness* mechanism implies that a major innovation can only become widely used after the development of complementary innovations in related or even unrelated industries. For example, the wide application of electric lighting could only be realised after the development of electric generators, transmission networks and even electric meters for private consumers or households.

Lastly, the *technical interdependency mechanism* concerns occurrences when one key technology 'gives birth' to many others. For example, the development of synthetic colours in the second half of the 19th century led to the emergence of many other branches of chemical industry, such as the production of pharmaceuticals, photography, plastics and so forth.

As noted above, the defining characteristic of clusters is their tightly interlinked character. The development of new clusters typically has a disruptive character, as new clusters undermine existing technoeconomic and institutional structures. At the same time, new clusters engender the creation of new knowledge, skills, institutions and so forth.

For the period from 1750 up to 1920, Boschma distinguishes seven clusters grouped in three stages (see Figure 10).

For the *First Industrial Revolution* (1770-1800), the *steam-coal-iron* and *textile-chemical* clusters are distinguished. The former cluster includes mechanical engineering (steam engines), iron making, coal mining, as well as various applications of the (stationary) steam engine. This cluster became fully developed in Belgium in the wake of its development in England. The latter cluster included mechanical engineering (textile machinery), the mechanised production of textiles as well as developments of the chemical industry (bleaching). While mechanical engineering and textile production developed in Belgium as well, the chemical industry lagged behind.

The *Railway Phase* (1830-1850) included one cluster only, the *steam-transport-iron cluster*. It included advances in mechanical engineering, in particular the high-pressure steam engine and new types of steam boilers for locomotives and steamships, plus better iron-making, shipbuilding as well as transport (railways, steam navigation), communication (telegraph) and finance. This cluster developed fully in Belgium, except for shipbuilding, which remained on a limited scale. Of particular importance was the development of the banking sector.

Lastly, the *Second Industrial Revolution* (1870-1900) included as many as four clusters: the *steel cluster*, *carbo-chemical cluster*, *electrical cluster* and *mechanical cluster*. The steel cluster refers to new steel-making techniques. The carbo-chemical cluster encompassed the production of synthetic dyes as well as many other chemical products (celluloid film for photography, pharmaceuticals). The production of sulphuric acid and coke are included in this cluster as well. The electrical cluster includes electricity generation and transmission, as well as electro-metallurgy and electro-chemistry. The mechanical cluster refers mostly to the production and application of internal combustion engines, including in the automotive sector. According to Boschma, all these clusters developed dynamically in Belgium, with the exception of the carbo-chemical cluster.[1058]

The framework as outlined above will be applied in the following chapters in order to better understand and contextualise the development of window-glass technology. To what degree was the glass industry indebted to other industries for its technological advancements? Which mechanisms were thereby at work? Can it fit within the framework of clusters as described above, or could it be regarded as a cluster on its own, due to the specificities of the glass-production technique? Are general trends in the development of technology reflected in the glass industry?

This theory provides a good framework for the analysis and conceptualisation of technological developments that occurred during the 19th century. Yet there is one fundamental flaw. As indicated by the name itself (clusters of innovative industries), it focuses on innovations specifically, while the 19th-century industrial development was defined by the combination of innovations and the persistence of older, often manual techniques (craftsmanship). In order to understand the industry fully, this aspect should be taken into account as well.

Innovation and tradition in the era of industrialisation

What defined an industry as truly ‘modern’ during the 19th-century industrialisation? Or, to put it in other words, how did different industries experience the transition from ‘traditional’ craft production to ‘modern’ industrial organisation during this crucial period, and how can we ‘draw the line’ between these two modes of production? How did the relationship between human skill (or craftsmanship) and modern technology change during the process?

The views on the Industrial Revolution have changed a great deal since the term was (presumably) used for the first time in academic historical writing by Arnold Toynbee in his *Lectures on the Industrial Revolution* in 1884. Toynbee spoke of a sudden, rapid and drastic change, epitomised by the ‘mighty blows of the steam engine’.[1059] This ‘traditional’ view was

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[1058] Boschma, “The rise of clusters of innovative industries in Belgium,” 853-871.
[1059] David S. Landes, “The Fable of the Dead Horse; or, The Industrial Revolution Revisited,” in *The British Industrial Revolution: An Economic Perspective*, ed. Joel Mokyr (Boulder, Colorado: Westview Press, 1993), 134.

seriously challenged by the revisionist approach of the quantitative (cliometric) school, which reached its heydays in the 1970s and 1980s. This school pointed to the fact that the rate of economic growth was much lower than presumed, while the adaptation of new technologies, such as steam power, was slow and piecemeal, especially outside the 'glamour sectors' of textiles and iron. The validity of the concept of the Industrial Revolution itself has since then been questioned.[1060]

This 'gradualist school' (or 'the new orthodoxy', as it was called by its critics) did not remain unchallenged either. Critics pointed to the fact that innovations, by their very nature, 'start small', and that there is always a considerable time lag between the first occurrences of new technologies and the moment when they start to influence the general statistics. Hence, quantitative analyses tend to 'conceal' nascent, yet important innovations. Moreover, it was pointed out that innovation has many faces. For instance, as Maxine Berg and Pat Hudson have noted, small handheld tools (alongside 'mighty machines') or organisational changes were important forms of innovation as well.[1061] In their wake, Joel Mokyr spoke of 'technological creativity' that went beyond 'great inventions' and included the ability to adapt inventions made elsewhere. He made a distinction between *micro-inventions* ('small, incremental improvements to known technologies') and macro-inventions ('dramatic new departures, that opened entirely new technological avenues by hitting on something that was entirely novel and represented a discontinuous leap with the past').[1062]

An important analytical concept that emerged in the course of the discussion is the 'dual-economy model', which makes a distinction between traditional and modern sectors of an economy. Mokyr, for example, puts agriculture, construction, domestic industry and various 'trades' in the former and cotton, iron, engineering, heavy chemicals and some others in the latter.[1063] The distinction between the two is not straightforward either, however. As argued by Berg, traditional sectors experienced many innovations of various kinds as well, resulting in a hybrid view.[1064] In this context, the question of skill and craftsmanship is important. In fact, manual labour and human skill remained essential in many sectors (including those that could be described as 'modern' in Mokyrian terms) during early industrialisation, and in quite a few cases even until the late 19th century.[1065]

'De-skilling' has often been seen as a central aspect of industrialisation, due to both the replacement of skilled workers by machines and the division of labour.[1066] However, as it was noted by Göran Rydén and some other authors in the context of the 19th-century iron industry, the technological innovation process tended to cause the replacement of some

[1060] Ibidem, 144-147; Berg, "Revisions and Revolutions," 43-45.
[1061] Berg, "Revisions and Revolutions," 56-59; Berg and Hudson, "Rehabilitating the Industrial Revolution," 30-35.
[1062] Mokyr, "Editor's Introduction: The New Economic History and the Industrial Revolution," 18-19.
[1063] Ibidem, 11.
[1064] Berg, "Revisions and Revolutions," 53-56; Berg and Hudson, "Rehabilitating the Industrial Revolution," 30-32.
[1065] John Rule, "The Property of Skill in the Period of Manufacture," in *The Historical Meaning of Work*, ed. Patrick Joyce (Cambridge: Cambridge University Press, 1987), 99-102; Samuel, "Workshop of the World," 17-21.
[1066] Paul Thompson, *The Nature of Work: An Introduction to Debates on the Labour Process* (London: Red Globe Press, 1983), 90-119.

skills by others rather than simple de-skilling.[1067] Here again, the technological transition process appears to have been much more complicated than a simple linear view would imply. Moreover, the significance of skill transcended the mere 'practical' aspects (an ability to perform certain tasks). Skilled workers tended to use it as a means of social distinction of their professional communities, claiming a 'property of skill' by insisting on such things as apprenticeships in order to limit the entry of outsiders. 'Owning' a skill was a great source of pride as well. Clearly, skills acquired a truly symbolic significance.[1068]

In short, in order to understand the process of industrialisation better in all its complexity, it is at least necessary to take the study of technological change beyond the well-known 'glamour sectors' of textiles and iron and steel. The study of 'traditional' sectors (or sectors that have been regarded as traditional) can be revealing as it allows us to see how important innovations could develop within more 'backward' settings. In more general terms, it can show us the working of technological creativity beyond the heroic narrative of great inventors and singular milestones. The case of the window-glass industry is particularly interesting in this respect, as it combined important 'modern' technological innovations with traditional work methods.

In order to evaluate technological change within a given industry, criteria are needed. David Landes mentions the following technological changes as essential for the Industrial Revolution, and hence the distinction between 'modern' and 'traditional' sectors: (1) the substitution of mechanical devices for human skills; (2) the replacement of human and animal strength by inanimate power, in particular steam; and (3) improvements in the procurement and use of raw materials, especially in the metallurgy and chemical industry.[1069] To these, the development of coal-using (thermal) technology can be added. It is true that the substitution of coal for firewood and charcoal in most industrial processes predates the Industrial Revolution by almost a century in England (much less so on the Continent).[1070] Nevertheless, the development of coal-burning technology (mostly within metallurgy) made such tremendous advances during the Industrial Revolution, that it can be seen as an integral part as well.[1071]

These criteria largely correspond to Boschma's *steam-coal-iron* innovations cluster of the First Industrial Revolution. However, important developments in thermal technology (melting furnaces) took place in the context of the *steel cluster* during the Second Industrial Revolution. Moreover, the substitution of mechanical devices for human skills was a long process that stretched throughout the entire 19th century, depending on the industry, as attested by Samuel, as mentioned previously.

The (Belgian) window-glass industry provides an interesting case in this context. It is generally characterised as traditional and technologically conservative in the Belgian

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[1067] Göran Rydén, "Skill and Technical Change in the Swedish Iron Industry, 1750-1860," *Technology and Culture* 39, no. 3 (Jul. 1998): 383-388.
[1068] Rule, "The Property of Skill in the Period of Manufacture," 100-104.
[1069] Landes, *The Unbound Prometheus,* 1.
[1070] Rolf Perter Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution*. Cambridge: The White Horse Press, 2001, 88-89.
[1071] Rydén, "Skill and Technical Change," 384.

historiography. This assumption is based on two arguments. Firstly, the usage of steam power was quite limited within the industry. Secondly, the manual skills and tacit knowledge of the workers (glassblowers) remained of paramount importance to the industry. The few innovations that did occur, such as the invention of the Biévez annealer in 1867 or the introduction of the tank furnace around 1885, are typically seen as exceptions to the rule.[1072]

Among others, Christian Mille provides a similarly negative assessment of the technological innovation in the window-glass industry in general in his thesis (1982). In the 19th century the industry would have merely 'borrowed' innovations from other industries (such as new types of furnaces from the metallurgy sector, or new kinds of raw materials from the chemical industry) without any 'indigenous' innovations.[1073] More recent historiography on the technological development of the window-glass industry provides a much more balanced view in this respect. In particular, the development of glass-melting furnaces has received much attention from Michael Cable and Marie-Hélène Chopinet.[1074] Their work reveals that the development of glass-melting furnaces implied much more than just 'borrowing' technology from metallurgy. It was a complicated process that took place within the glass industry itself. Still, despite the value of this research, much remains to be said about the development of window-glass technology. These works are of a descriptive character, with little (if any) contextualisation within the general process of industrialisation as described above. The broader developments within Belgium do not receive any attention. However, as will be shown further, the Belgian industry did play an important role in the technological developments. It is therefore unfortunate that some important steps within the production process, such as annealing, are only briefly touched upon at best, as is also the case with the relationship between technological innovation and workers' skills.

Innovation of the production process

In order to answer the third research question of this part – how the innovations were put into practice – the following paragraphs will focus on the developments and practical implementations of innovations in the production process of window glass. First, a general survey of invention patents will be provided, using the same sample as in the analysis of patenting as a knowledge-management strategy. The following analysis is based on the same sample of patents as the one used in the previous chapter. However, while the previous chapter focused on more 'theoretical' aspects, such as the functioning of the patenting system in general and the broad categories of invention, the following analysis makes a more 'practical' distinction between various categories of inventions, such as annealers, melting furnaces (including accessories such as pots and gas producers), small tools and devices, chemical composition and components, mechanical production of glass and other/unknown.

[1072] Delaet, "La mécanisation de la verrerie à vitres à Charleroi," 123-127.
[1073] Mille, "Évolution de la branche verre plat," 87.
[1074] Michael Cable, "The Development of Glass-melting Furnaces 1850-1950," *Transactions of the Newcomen Society* 71, no. 1 (1999-2000): 205-227; Cable, "The world's first successful regenerative furnace"; Michael Cable, "The advance of glass technology in the nineteenth century," *Glass Technology: European Journal of Glass Science and Technology. Part A* 61, no. 4 (2020): 115-126; Marie-Hélène Chopinet, "Developments of Siemens regenerative and tank furnaces in Saint-Gobain in the XIXth century," *Glass Technology: European Journal of Glass Science and Technology. Part A* 53, no. 5 (2012): 177-188.

After this, the adaptation of both ‘general purpose technologies’ such as steam power and electricity as well as the developments of industry-specific technologies like melting furnaces and annealers will be discussed in detail. The treatment of technologies will generally follow the same steps as the production process itself, from the auxiliary functions to the melting, shaping and annealing of the glass. Finally, using the theories of Boschma (clusters of innovative industries) and Berg & Hudson (the interplay between ‘traditional’ skills and ‘modern’ industrial technology) as a conceptual framework, the technological developments within the window-glass industry will be related to the general developments in the 19th century technology. This will enable us to arrive at a more balanced view regarding the assumed ‘backward’ character of the window-glass industry.

The analysis is based on a variety of sources. Alongside invention patents, requests for the establishment and expansion of window-glass factories form an important source. For instance, these requests are an exclusive source for the chemical components employed in the first half of the 19th century. Other sources, such as contemporary publications of various kinds (press, World Fairs’ reports) were employed as well.

General trends in innovative activity in the glass industry

According to Mokyr, there are two different ways to measure the level of technological change within a given industry (or an economy as a whole): the counting of patents (the microeconomic approach), and estimating the total factor productivity (the macroeconomic approach).[1075]

Some relevant macroeconomic data for the entire window-glass industry is provided by Douxchamps. They show that the production price of window glass fell sharply between 1823 and 1847 (although data for the first half of the century is difficult to interpret, he estimates the fall in price as 75 to 80%) after which it remained mostly stable until 1914.[1076]

How does this macroeconomic evolution relate to the technological inventive activity within the industry? In order to explore this question, I have conducted a quantitative study of the Belgian invention patents for the entire period of 1830-1914. Many (if not the majority) of patents were taken out by people who were directly connected to the glass industry as industrialists, engineers or workers. This strengthens the usefulness of patents as a source for the history of technology, as these patents were clearly related to the professional knowledge of their authors (patentees), hence making clear what practical problems were encountered. Nevertheless, as <u>a quantitative source for the history of technology</u> invention patents need to be used with a great deal of reservation, because of the inevitable omission of important aspects and trends. While I assume that an increase in patenting activity related to a specific step in a production process points to innovative activity in the sector, this can remain limited to a specific aspect, so that the patents reveal only *some* trends, not *all*. In particular, as already established in the previous part, chemical knowledge (glass composition and components) was underrepresented in invention patents. This should be attributed to the fact that this knowledge was managed in other ways, not that no innovation

[1075] Mokyr, “Editor’s Introduction: The New Economic History and the Industrial Revolution,” 23.
[1076] Douxchamps, “L’évolution séculaire de l’industrie du verre à vitres,” 476-477, 481-482.

in this area occurred. Specifically, thermic and mechanical knowledge (related to furnaces, annealers, tools and devices) was particularly represented in the patents.

The important question (and possible critique of the use of invention patents as a source for the history of technology) concerns the degree to which trends in patenting are indicative for the practical innovative dynamics in various industries. For Belgium, this question was addressed by Corentin de Favereau de Jeneret. He concluded that in most cases, the number of patents is indicative of the dynamics of a given industry. However, he discovered three exceptions: the weapons industry, the heating and lighting industry, and the chemical industry. All three sectors experienced positive dynamics while the number of patents declined in the second half of the 19th century. De Favereau de Jeneret provided the following explanations of this paradox. The weapons industry was still organised along the lines of a cottage industry to a large extent, which was, presumably, a less conducive environment for formal patenting. The decline in the number of patents for heating and lighting devices in the late 19th century can, at least partly, be explained by a change in the classification of patents in the official catalogue (*Recueil des brevets d'invention*), which listed all patents by category such as 'chemicals' or 'weapons', as the new category of electrical devices emerged. However, de Favereau de Jeneret could not provide any explanation for the stagnation and decline in the number of chemical patents.[1077] This is an interesting observation, as it shows that the near-absence of chemical patents in the window-glass industry was not an isolated phenomenon.

All in all, the examples provided by de Favereau de Jeneret show that in order to truly understand how patenting functioned in a given industry, it is necessary to conduct a qualitative study of the development of a given industry alongside a quantitative analysis of patenting trends.

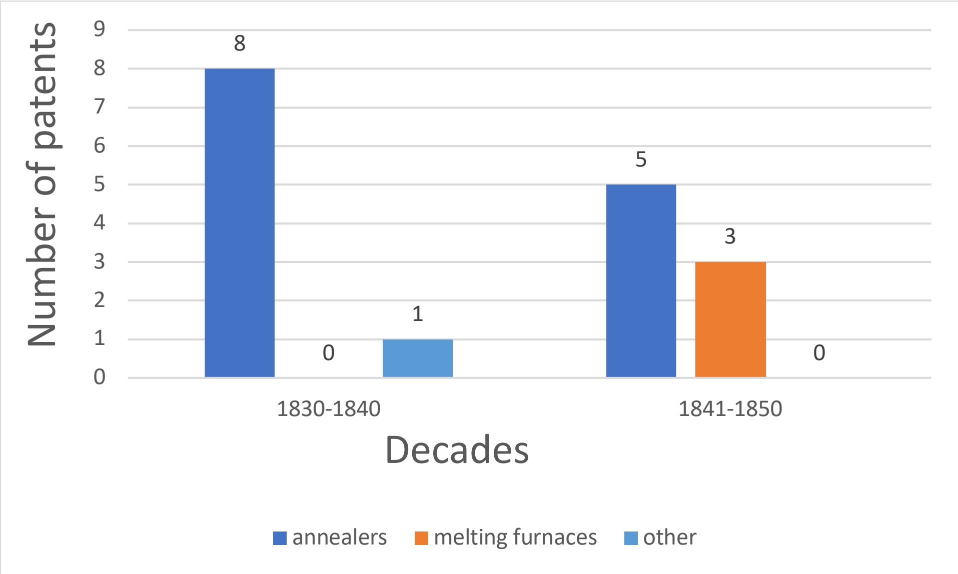
In the following paragraphs, the qualitative development of the production process will be analysed using various sources, such as requests for the establishment and expansion of factories and contemporary press. This qualitative analysis will serve to corroborate the quantitative analysis at least to some degree and counter biases emerging from the fact that some types of knowledge (chemical knowledge in particular) tended to be underrepresented in patents.

The general trends in patenting (without a breakdown into specific categories of devices and techniques patented) were already discussed in the chapter on patenting as a knowledge-management mechanism. To recapitulate, two waves of inventive activities were acknowledged: the first between 1830 and ca. 1860, and the second between approximately 1860 and 1895.

To take the analysis further to the 'practical' level and in order to understand what kind of innovations caused these waves, we will proceed to the analysis of the types of inventions that were patented, as represented by the Graphs 12, 13, and 14.

[1077] de Favereau de Jeneret, "Faire germer le progrès," 153-161.

Graph 12: Types of inventions in the Belgian window-glass industry (Belgian patents), 1830-1850 (n=17)

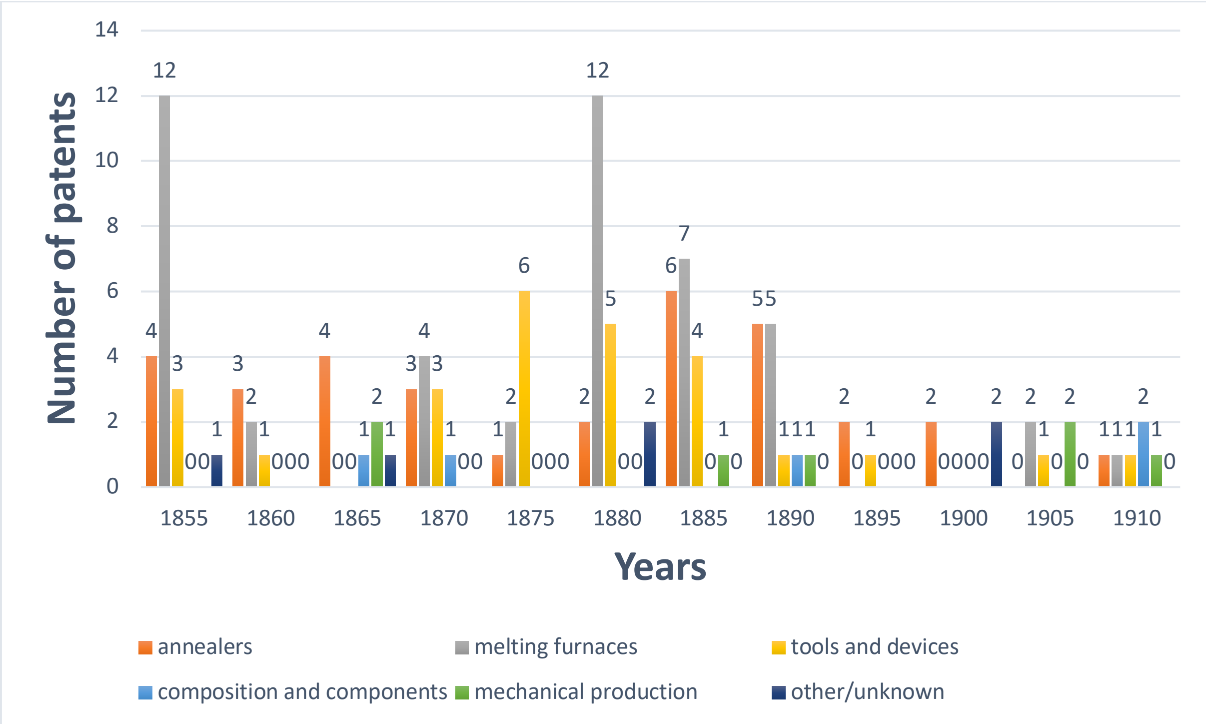


Source: sample by Vitaly Volkov, see Appendix for the full list

As for the foreign patents, only four were registered for the period 1830-1850: one for annealers between 1830 and 1840 and three 'unclear' (with descriptions such as 'various improvements of glass production') between 1841 and 1850.

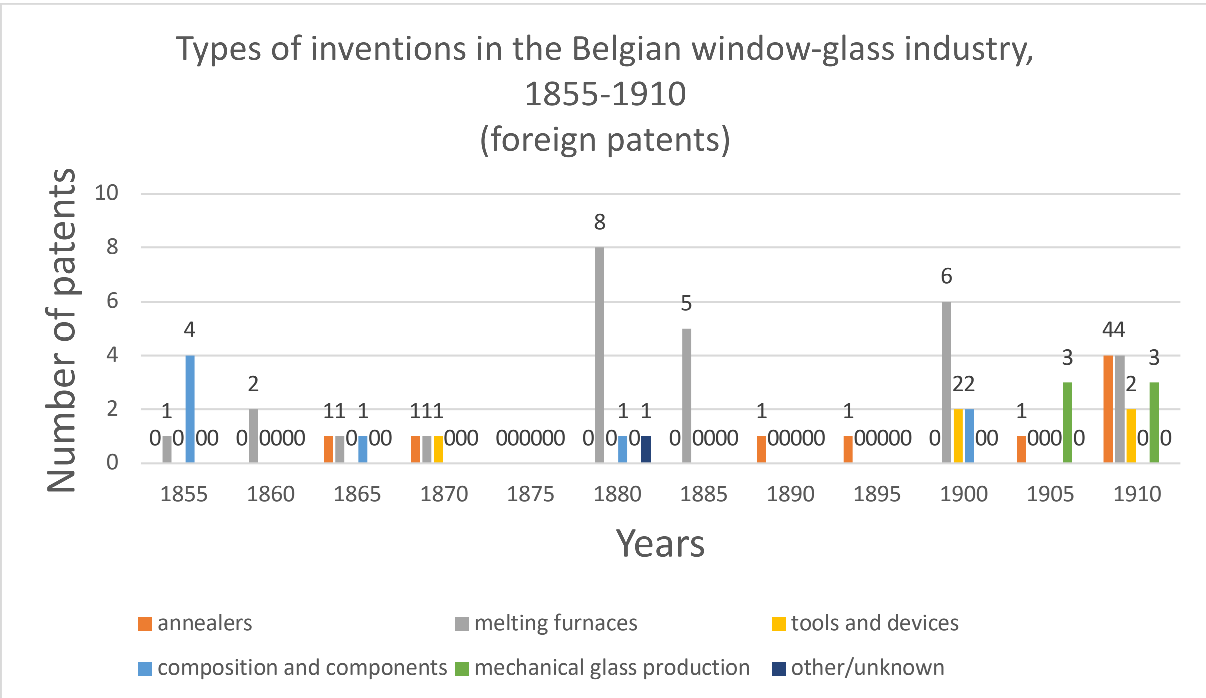
For 1830-1850, no inventions of the types 'tools and devices', 'components and chemical composition' and 'mechanical production of glass' were recorded. The lack of patents for components and chemical composition can be attributed to the low propensity to patent in this category of knowledge rather than to the lack of innovations in this field. The relatively large number of 'other/unknown' is due to vague descriptions within the registers, such as 'various improvements of glass production'. For this period, annealers were the most important types of inventions, followed by melting furnaces.

Graph 13: Types of inventions in the Belgian window-glass industry (Belgian patents), 1855-1910 (n=118)



Source: sample by Vitaly Volkov, see Appendix for the full list

Graph 14: Types of inventions in the Belgian window-glass industry (foreign patents), 1855-1910 (n=56)



Source: sample by Vitaly Volkov, see Appendix for the full list

After 1855, and especially between 1875 and 1890, two types of inventions rose to prominence: melting furnaces, and various kinds of tools and other devices. None of these devices was powered by steam or any other means of mechanical propulsion. They were not 'machines', but small and relatively simple devices that were mostly intended to assist glassblowers. Tables and tools for cutting glass are also included in this category. Annealers were featured as well.

The rising share of foreign patents around 1880-1885 was connected to the development of melting furnaces. Clearly, this innovation was much more international in character than annealers.

Now some trends in technological development have been made visible, we will proceed further by analysing how various aspects of the glass-production process evolved during the period under consideration. This will allow us to understand the general trends better by supplementing quantitative data with qualitative research on technological development. We will start by researching how steam power was applied within the industry. Then, we will analyse the raw materials and the three main steps within the production process, i.e. melting, shaping and annealing.

Steam power and electricity in the glass industry

Steam power and electricity are known to be the key technologies of the First and Second Industrial Revolution, respectively. Therefore, the adaptation of these 'general purpose technologies' by various industries is often regarded as a proxy of innovation and modernisation in general. It is therefore relevant to see how these technologies were adopted by the window glass industry.

None of the patents within the sample concerned any kind of steam-powered machinery. This does not mean that steam power was not used in the window-glass industry. The 'mighty blows of the steam engine' could be heard in glass factories as well, albeit less loudly and prominently than in the cotton mills, for example. For the glass industry the steam engine was a 'borrowed technology', which was adopted without much further industry-specific development. The information on the use of steam power in the window-glass sector can be found in the requests for the permissions for establishments and expansion of factories, statistics (industrial censuses) and some other sources.

The first steam engine within the window-glass industry of Belgium was introduced in 1828 at the *Verreries de Mariemont* factory.[1078] It remained the only steam engine within the window-glass industry until 1837, when the *Verreries Frison* factory started to use one.[1079] By

[1078] E. Stanier, "Notice sur les premières machines à vapeur établies dans le district de Charleroi," *Documents et rapports de la société royale d'archéologie, d'histoire et de la paléontologie de Charleroi* 6 (1878): 478-481.
[1079] State Archives of Belgium, depot Mons (further: ARA-Mons), Chambre de commerce, dossier 343, Situation de la industrie verrière pour 1837

1850, roughly one third of all window-glass factories had a steam engine.[1080] By 1896, all factories used at least one.[1081] By 1910, the average engine power per factory amounted to 46 horsepower (hp). At the plate-glass factories, where more mechanical power was needed to polish the glass, the average power per factory was even as high as 2,295 hp, while in the mechanical engineering industry (machines and metal construction) it amounted to 12.5 hp per factory, and within the furniture industry a mere 0.7 hp per factory.[1082]

Obviously, this mere quantitative data on the use of steam power is insufficient to judge whether an industry was 'modern' or 'backward'. It is essential to look at the way in which the steam engines were used in order to arrive at a more balanced assessment. As various industries differed in their production processes, the need to use steam power was different as well.

In the window-glass industry, the primary use of steam engines was to mill and mix the raw materials. This can be revealed from sources from the 1830s and 1840s.[1083] In the second half of the 19th century, other uses started to emerge. For example, steam engines were then used to drive ventilation equipment or pump water (in particular, cold water was used for the cooling of the glassblower's canes[1084]).[1085] As already discussed in the chapter on agglomeration effects, steam machines were widely used by the window-glass industry in the last decades of the 19th century.

From the late 1880s, factories started to use steam engines to produce electricity, at first, most probably, for lighting. One of the first recorded cases dates to 1888, when the *Verreries Baudoux* applied for a permit to install a new steam machine in order to drive an 'electric machine' (generator) as well as other (non-electric) pieces of equipment, such as ventilation and a mill to pulverise raw materials.[1086] By the First World War, electric power was used for many other purposes, at least by the most progressive enterprises. For instance, the *Verreries des Piges* had nine electrical motors in 1916, which were used to power lifting equipment (overhead cranes), to mill and mix raw materials and to saw wood for packaging. The use of steam power was not reported anymore; the factory seems to have been fully electrified by then.[1087]

In short, steam engines were not the 'primary movers' of the industry, but they were used where necessary, especially after 1850. The utilisation of electricity from the 1880s on, and

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[1080] Anne Van Neck, *Les débuts de la machine à vapeur dans l'industrie belge 1800-1850* (Brussels: Académie Royale de Belgique, 1979), 575, 706; Poty and Delaet, *Charleroi pays verrier,* 72; *Journal de Charleroi*, 7 juillet 1852

[1081] Ministère de l'Industrie et du Travail. Office du Travail, *Recensement général des industries et des métiers (31 octobre 1896),* vol. XV, cadre XIII, 30-31.

[1082] Ministère de l'Industrie et du Travail. Office du Travail*. Recensement de l'industrie et du commerce (31 décembre 1910),* vol. VIII, 272, 267, 269.

[1083] For example: "Statuts Société de Dampremy," in Vol. 2 of *Collection des statuts de toutes les sociétés anonymes et en commandite par actions de la Belgique* (Brussels: Trioen, 1839), 343-347; ARA-Mines, nr. 776 dossier 1671 and nr. 778, dossier 582

[1084] Poty and Delaet, *Charleroi pays verrier*, 130.

[1085] AvCh, Établissements, DA, BT 22, dossier nr. 698 and Établissements, JU, BT 110, dossier nr. 3379

[1086] AvCh, Établissements, JU, BT 110, dossier nr. 3379

[1087] Archives Musée du Verre, Charleroi, Unclassified documents, document Verreries des Piges, 29 September 1916 the full electrification of at least some factories by 1914 indicates that the window-glass industry was certainly not slow in adopting this new technology.

Components

The basic components of ordinary clear (colourless) window glass are silica (sand, SiO_2), flux (alkali) and stabiliser (lime). Of these three, the production and use of flux changed most between the late 18th and early 20th century.

The function of alkali is to reduce the melting temperature, hence the name flux. While pure silica melts at around 1,700 degrees Celsius, the use of flux lowers the melting temperature to between approximately 1,200 and 1,400 degrees. During the Middle Ages and the Early Modern period, the main sources of alkali for glass production were the ashes of burnt wood (elm, oak and, especially, beech were considered as best for this purpose) that contained K_2O, known as potash, and the ashes of marine plants (seaweed or coastal plants that grew in saline environments) that contained Na_2O and were known under different names, depending on their provenance, such as *barilla* (Spain, especially Alicante), *kelp* (England) or *varech* (France), commonly known as soda. The potash glass was more common in north-western Europe, while soda glass dominated in Italy and the Mediterranean region. While reducing the melting temperature, flux made glass less chemically stable and durable. To counter this negative effect, a stabiliser (mostly lime, CaO) was added to the composition.[1088]

The window-glass composition did not remain constant during the long period between the Middle Ages and the 19th century. In present-day Belgium, two main glass compositions appear, potash glass (high K_2O concentration, up to 15 to 20%w) and high-lime-low-alkali glass (HLLA, low K_2O concentration, 5 to 7%w). The HLLA glass contained some Na_2O, indicating the use of soda in the composition. The potash glass dominated in the late Middle Ages and was largely (but not completely) replaced by the HLLA glass from the 15th century onwards. In the late 17th century, potash glass made a comeback, largely replacing the HLLA glass. Purified potash was then used to assure better quality.[1089]

At the end of the 18th century, a revolutionary process to produce soda artificially was invented in France. By the late 18th century, this country mostly relied on imported soda (Spanish *barilla*) as an alkali source for glass production. The rising price of alkali (potash and barilla) became such an issue that the French Academy offered a prize for the best process for making soda from common salt. The situation worsened with the outbreak of the

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[1088] Bontemps, *Guide du verrier*, 50-75; David Dungworth, “The Value of Historic Window Glass,” *The Historic Environment: Policy and Practice* 2, no. 1 (June 2011): 29-42; Marie-Hélène Chopinet, “Chimie industrielle et innovations dans les compositions verrières, fin XVIII-XIXe siècle, ” in *Actes du deuxième colloque international de l’association verre & histoire, Nancy, 26-28 mars 2009*, Online access http://www.verre-histoire.org/colloques/innovations/pages/p302_01_chopinet.html ; Marie-Hélène Chopinet, “The history of glass,” in *Springer handbook of glass,* eds. J. David Musgraves, Juejun Hu and Laurent Calvez (Cham: Springer, 2009), 7-8, 16; Douglas and Frank, *A history of glassmaking*, 22-23; O. Schalm et al., “Chemical composition and deterioration of glass excavated in the 15th-16th century fishermen town of Raversijde (Belgium),” *Spectrochimica Acta Part B* 59, no. 10-11 (2004): 1648.

[1089] Caen, *The production of stained glass*, 122-126; Olivier Schalm et al., “Composition of 12-18th century window glass in Belgium: Non-figurative windows in secular buildings and stained-glass windows in religious buildings,” *Spectrochimica Acta Part B* 62 (2007): 664-668.

revolutionary wars, as imports of soda were hampered by the continental blockade, while the domestic potash production was consumed by saltpetre and powder manufacturers.

The solution was found by the chemist Nicolas Leblanc, who invented the chemical process and started industrial production in 1791. The Leblanc process consisted of two steps. First, common salt (NaCl) was heated with sulphuric acid, forming sodium sulphate (Na_2SO_4, also known as ‘saltcake’). Then, the ‘saltcake’ was heated with lime and carbon (charcoal or coal), forming sodium carbonate (Na_2CO_3), or just artificial soda. After a range of initial problems (Leblanc committed suicide in 1806, tired of misfortunes), the production of artificial soda became established in France around 1810. At first, only sodium carbonate was used for glass production. The utilisation of the intermediary product of sodium sulphate (‘saltcake’) was problematic for various reasons. First and foremost, it did not easily combine with silica. This problem was solved in 1813 by the German chemist Gehlen, who discovered that the decomposition of sodium sulphate (and hence melting of the glass) was aided by adding limestone and coal to the mixture. Moreover, Gehlen elaborated exact proportions of a mixture of sodium sulphate with limestone and coal, which could melt well.[1090] In France, the use of sodium sulphate for glass production started in 1824. According to the manual by De Fontenelle, published in 1829, using sodium sulphate it was possible to produce glass that would not be of lesser quality than that produced using potash. Basing his assessment on experiments that were carried out by François Baader and Gehlen (first name not mentioned) De Fontenelle prescribed the usage of coal as a ‘purifier’ for sodium sulphate.[1091] Yet, another problem remained. The glass produced with it had a greenish shade. It took chemists decades to understand the exact reason and a way to eliminate it. It was only in the 1850s that the French chemist Pelouze figured out that the shade was due to a contamination with iron oxide, and he developed an effective purification process.[1092]

The switch from sodium carbonate to sodium sulphate was a long and complicated process. An influential manual on practical chemistry, written by Arsène Payen and published in 1851, mentioned explicitly that sodium sulphate was used for window-glass production in Germany and France.[1093] Nevertheless, writing as late as 1868, Georges Bontemps, an influential French glass technologist, noted that the use of sodium sulphate was still not very widespread. He also noted that the sulphate glass was always of a somewhat lesser quality than the carbonate glass.[1094]

In Belgium, several Leblanc-soda factories were established from 1822 onwards, as already discussed in Part 2, Chapter 2.1. However, the domestic production of artificial soda remained insufficient, and the window-glass industry remained dependent on foreign imports throughout the 19th century, as discussed in more detail in the chapter on the sources of raw materials. The introduction of artificial soda (sodium sulphate) in the Belgian window-glass industry took place in the first half of the 19th century. This process can be attested by the multiple requests for the establishment and expansion of factories, as they provided data on the consumption of raw materials. Before the introduction of artificial soda,

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1090 Bontemps, *Guide du verrier*, 58.
1091 de Fontenelle, *Manuel complet du verrier,* 119-122.
1092 Chopinet, “Chimie industrielle et innovations”; Chopinet, “The history of glass,” 18.
1093 Arsène Payen, *Précis de chimie industrielle* (Paris: Librairie de L. Hachette et C[ie], 1851), 322-323.
1094 Bontemps, *Guide du verrier,* 56-62, 71.

various sources of flux were used in the early 19th century. For instance, the usage of 'salins' (which can be interpreted as purified plant ashes or potash[1095]) was reported around 1810-1811 by several factories.[1096] The use of *varech* alongside unspecified 'sels bruts' (brute salts) was also reported by one factory in 1810. It is not clear why two types of flux were used simultaneously. Possibly, they were used for various products, as the factory produced various qualities of window glass alongside bottles.[1097] As late as in 1826-1828 one factory reported the use of 'salins' as well.[1098] In 1823, even the use of *barilla* was reported in one case.[1099] In the same year, another factory reported the use of both potash and 'soude' (most probably, sodium carbonate). While the potash was sourced from 'this country' (the United Kingdom of the Netherlands at that moment), the sodium carbonate was imported from France.[1100]

The year 1823 marks the first recorded use of artificial soda in present-day Belgium, although the interpretation is not entirely clear. The request mentions a mixture that, most probably, functioned as flux. It consisted of 25% 'salin', 25% 'sel de soude' and 50% 'sulfate'.[1101] As mentioned above, 'salin' consisted of purified plant ashes (potash), while 'sel de soude' stands for sodium carbonate, which makes this the first mention of artificial soda.[1102]

The turning point in the use of artificial soda as flux seems to be situated around 1834-1836. In 1834, one factory reported the use of four sources of flux at the same time, namely sodium carbonate, sodium sulphate, 'salin' (purified potash) and potash, while another one used sodium sulphate alongside 'salin'.[1103] From 1835 on, all factories mention the use of sodium sulphate only.[1104] This is quite remarkable because, as mentioned above, according to Bontemps the use of sodium sulphate in France did not become widespread until the 1860s. The greatest advantage of using sodium sulphate instead of sodium carbonate was its price, as the former was five times cheaper than the latter.[1105]

One of the few Belgian invention patents dedicated to the chemical aspects of glass production was related to the use of sodium sulphate. In it, the patentee described the common process, and proposed his own. According to the patent, the commonly followed way to use sodium sulphate, consisted of mixing it with coal, sand, and limestone. In this way, sulphate was reduced (underwent a chemical reduction reaction) by the working of added coal while the mix melted to form glass. This is reminiscent of the aforementioned method described by De Fontenelle. The patentee proposed reducing sodium sulphate with coal and limestone before the melting itself. Only after this, would sand be added to the

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[1095] Bontemps, *Guide du verrier,* 66; Payen, *Précis de chimie industrielle,* 201-203.
[1096] ARA-Mines, nr. 778, dossier Verrerie Falleur; nr. 778 dossier Verreries Falleur Jumet; nr. 778 dossier Verrerie Desandrouin
[1097] ARA-Mines, nr. 778, dossier Verrerie Delobel
[1098] ARA-Mines, nr. 778, dossier Verrerie Depermentier
[1099] ARA-Mines, nr. 778, dossier Verrerie Dorlodot-Levieux
[1100] ARA-Mines, nr. 776, dossier verreries Zoude-Drion
[1101] ARA-Mines, nr. 776, dossier 992
[1102] A. F. Fourcroy, *Système des connaissances chimiques et de leurs applications aux phénomènes de la nature et de l'art,* Vol. 4 (Paris: Institut national des Sciences et des Arts, 1800), 3-10, 36-43.
[1103] ARA-Mines, nr. 776, dossier 1429; nr. 776, dossier 2057
[1104] Some examples (not exhaustive): ARA-Mines, nr. 776, dossier 2134; nr. 777, dossier 1722; nr. 778, dossier 582
[1105] Chopinet, "The history of glass," 18.

mixture in order to produce glass. The patent claimed that his process would eliminate inconveniences caused by the release of carbonic acid during the melting of glass, and speed up the melting process. It is not known whether the invention was ever put into practice, but it gives us an idea how sodium sulphate was used in the Belgian window-glass industry around 1855, when his patent was registered.[1106]

The next step in the development of chemical components was taken in 1863, when Ernest Solvay discovered his process to turn common salt (NaCl) directly into sodium carbonate (Na_2CO_3), using limestone (calcium carbonate $CaCO_3$) and ammonia (NH_3). Unlike the older Leblanc process, this new Solvay process proceeded in one step (avoiding the intermediary production of sodium sulphate), which allowed for yet another significant price reduction. The first Solvay factory started working in 1865 in Couillet near Charleroi. Nevertheless, the transition from sodium sulphate to sodium carbonate as a source of flux for the window-glass industry was surprisingly slow. In France, the first trials were (rather unsatisfactorily) conducted in 1906, and the full transition only occurred in the 1920s.[1107]

In Belgium, too, the replacement of sodium sulphate by sodium carbonate proceeded slowly in the glass industry. As attested by statistics provided in a contemporary article on the state of the Belgian glass industry by Lalière, in 1913 the entire Belgian window-glass production (clear window glass, as well as coloured and special window glass) consumed 72,568 tons of sulphate and only 1,078 tons of carbonate.[1108] As noted explicitly in 1907 in *Fabrication et travail du verre*, sodium carbonate (Solvay soda) was used for the production of plate glass, as well as crystal and hollow glass (*gobeleterie*), while for the production of ordinary clear window glass as well as bottles, sodium sulphate was still preferred, with the addition of small quantities of sodium sulphate (Leblanc soda) in some cases. It should be noted that the word *soude* was used for carbonate as well as sulphate, so that the exact interpretation is dependent on the context. Interestingly, carbonate was preferred for the production of coloured window glass.[1109] In order to reduce the sulphate, carbon was added to the melt in the form of charcoal or coke.[1110]

Clearly, almost fifty years after the invention of the Solvay process, it still remained marginal as far as the production of window glass is concerned. The linkages between the glass and chemical industries concerned plate glass in the first place. As already discussed in the context of raw materials, most of the Belgian soda factories were literally integrated with plate-glass factories. In the first half and middle of the 19th century, when window-glass production relied on Leblanc soda, the Belgian chemical industry proved to be incapable of meeting the demands of the Belgian window-glass industry, as most of its production was consumed by the plate-glass factories. Moreover, soda was also consumed by other industries, such as the producers of detergents, bleach and pigments, fertilisers, soap and paper.[1111] As noted above, by the early 20th century the 'new' Solvay soda was used for the

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[1106] ARA-2, brevets, brevet numéro indicateur 1933 (1855)
[1107] Chopinet, "The history of glass," 18-19.
[1108] Lalière, "Le verre en Belgique," 598-634.
[1109] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 14.
[1110] Ibidem, 18.
[1111] Linters, *De wortels van Flanders Technology*, 167.

plate-glass production primarily, while window-glass production still largely relied on the 'old' Leblanc soda.

In the early 20th century, according to the *Fabrication et travail du verre*, the most common composition of window glass was as follows: 73.31% silica, 13.08% *soude* (to be interpreted as sulphate), 13.24% lime and 0.85% iron oxide (to be interpreted as contamination).[1112]

To these basic components, some others could be added in small quantities. For example, arsenic was added in some cases as it was believed to facilitate melting.[1113] Especially when using pot furnaces, arsenic was often thrown into the pots. Due to its high density, arsenic sunk into the melt, and then vaporised quickly. The escaping vapours of arsenic 'stirred' the glass, thus facilitating the melting process and 'purging' the so-called 'seeds' (not completely molten particles) within the molten mass.[1114] In order to avoid the undesirable greenish tint that appeared due to the iron oxides, which were present in all but the most pure sands, manganese dioxide (MnO_2, also known as 'glassmakers soap', *savon des verriers*) was often also added.[1115]

Concluding this section, a short note on the chemical composition of coloured glass will be presented. As already mentioned in the chapter on knowledge management, many recipes for coloured glass were available from treatises published from the 18th through the 19th centuries. Without going into too much detail, the primary colouring agents that were used by the late 19th-early 20th centuries can be summarised as follows. The blue colour was acquired using cobalt oxide. Green (of various shades) could be acquired using chromium oxide (pure or in combination with other components), while copper oxide resulted in a turquoise (green-blue) shade. Yellow resulted from the combination of carbon (in the form of charcoal) and sulphur. Of all colours, red was the most difficult to produce. The purple of Cassius (product of a reaction of gold salts and tin chloride) resulted in a ruby shade. A 'reddish shade' could be produced with cuprous oxide (Cu_2O rather than CuO used for turquoise).[1116] In fact, true red could only be produced with Cu_2O as a thin red layer (coating) on top of a thick sheet of clear glass.[1117] Opal glass was produced by the combination of kaolin (China clay) with cryolite and various colouring components.[1118] This is by no means an exhaustive list, as the number of recipes for coloured glass is extensive. The detailed treatment of coloured glass goes beyond the primary scope of this study, that being clear window glass first and foremost.

1112 Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 3.
1113 Bontemps, *Guide du verrier*, 93-94 ; Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, *Fabrication et travail du verre*, 20.
1114 S. R. Scholes, "Methods of Melting Glass," *Industrial & Engineering Chemistry* 25, no. 8 (1933): 870-872.
1115 Bontemps, *Guide du verrier*, 89-93; Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 20.
1116 Bontemps, *Guide du verrier*, 79-109; Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 24-28.
1117 Bontemps, *Guide du verrier*, 101-103; Caen, *The production of stained glass,* 231.
1118 Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, p. 26-27.

Melting furnaces

The melting furnaces are used to melt the raw materials, such as silica (sand), flux (alkali) and stabiliser (lime) at temperatures around 1,200 to 1,400 degrees Celsius. The history of furnace technology is mostly defined by the fuel, i.e. various kinds of fuel and their characteristics, and by a strive for fuel efficiency. This is not surprising given the fact that glass production required very large quantities of fuel. Until the end of the 19th century, the fuel consumption amounted to three to seven times the weight of the glass produced.[1119]

Traditional furnaces and their shortcomings

Traditionally, two types of furnaces were used: a rectangular type, which was first described by Theophilus in the 12th century and was popular in northern Europe; and the beehive-type, which was described by Agricola in his famous *De Re Metallica* (1540) and was more popular in southern and Mediterranean regions (the geographical spread of both types should not be taken as an absolute rule). Both types used crucibles to melt the raw materials and were fired with wood.[1120] Furnaces did not change a lot until the substitution of coal for wood.

In general, the transition from firewood (and charcoal) to coal was no trivial matter, as it required a certain degree of technological innovation and practical experimentation. In England, where wood was becoming increasingly rare while coal was relatively cheap, most industries (limestone burning, salt melting, brewing, etc) had already switched to coal in the 17th century, with the iron industry remaining a notable exception until the invention of coke in the 18th century. The main disadvantage of coal was its 'dirtiness', as it contained multiple chemical substances that could contaminate the manufactured product and diminish its qualities. Hence, the equipment used (furnaces, ovens, pots and the like) needed to be adjusted in a way to limit or prevent any contact between gases and product. Another solution, which was particularly important in metallurgy, consisted of removing the harmful substances from the fuel itself by turning coal into coke.[1121]

The English glass industry was required to use coal exclusively from 1615 onwards, as King James I forbade the use of wood for glassmaking in order to preserve forests. The adaptation of coal caused important changes to the furnace design. Unlike wood-fired furnaces, coal-burning required a long underground tunnel that led a large amount of air necessary to the grate in the centre of the furnace where the coal was burnt. At the same time, the roof was made in the form of an arch or a vault in order to strike the heat back to the materials to be melted (the reverberatory principle).[1122] The study of various 19th-century treatises on glass production clearly indicates that firewood was regarded as a much better fuel than coal. According to Loysel (1791), truly fine-quality glass could only be made in a wood-burning furnace. De Fontenelle (1829) shared this opinion more or less implicitly. Even Bontemps (1868) still mentioned that a wood-based flame was 'more pure and clean'. By this time,

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[1119] Chopinet, "The history of glass," 8.

[1120] Cable, "The Development of Glass-melting Furnaces," 205-206; Cable, "The classic texts of glass technology," 57.

[1121] Sieferle, *The Subterranean Forest*, 88-89.

[1122] Chopinet, "The history of glass," 12-13.

however, only a few glass factories in France still used firewood, although it was still used by the majority of factories in Germany. In order to prevent harmful contact between coal smoke and melting materials, open pots were replaced by closed ones. This necessitated higher temperatures in the furnace.[1123]

In present-day Belgium, the use of coal for glass-melting furnaces was first introduced in 1643, while in the majority of European countries, including France, wood remained the main fuel for glass industry even through much of the 19th century.[1124] The early introduction of coal in 'Belgium' was not surprising, as the energy regime in this part of the Continent most resembled the English situation. In Belgium as well, the shortage of 'traditional' fuels (peat and wood) became increasingly problematic from the 17th century on, while domestic coal extraction had started already in the 13-14th century.[1125] Despite the early start, the transition did not happen overnight. At the beginning of the 18th century, the majority of glass factories in 'Belgium' still used firewood. The gradual transition took the entire 18th century. Just like in England, closed melting pots were introduced, while furnaces underwent modifications.[1126]

The transition was complete by the first decade of the 19th century, as attested by requests for the establishment and expansion of window-glass factories. Even the earliest requests, dating from 1810-1812 exclusively mention coal for melting purposes.[1127] The requests were accompanied by drawings of furnaces and allow us to draw conclusions about their construction. These drawings clearly show reverberatory vaults as well as air tunnels, just as was the case for the English coal-burning furnaces.[1128]

The construction of melting furnaces as described did not change a lot until the 1860s. Two important shortcomings were acknowledged from the middle of the 19th century. First, the method of working was mainly discontinuous. It proceeded in cycles, starting with the filling of the pots with components, heating the pots until the components turned into liquid glass, and finally the 'working' of the glass, whereby a glassblower took glass from the pot and blew the glass multiple times until the pot was empty. Secondly, energy efficiency was seen as poor. Both problems worsened as the growing demand for glass required an increase in production. In order to meet demand, the 'glass masters', as the owners of glass factories were known, mostly increased the size of the melting pots. According to the literature (Lefèbvre, 1938 and Drèze, 1913), at the beginning of the 19th century one pot contained 150 kg of glass, in 1860 it amounted to 600 kg and in 1875 as much as 1,200– 1,800 kg. However, this had an unfortunate consequence for the consumption of fuel, as larger pots required more fuel in relation to the quantity of glass produced. While in 1840, 260 kg of coal was needed to produce ten square metres of glass, in 1874 the same quantity of glass

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[1123] Loysel, *Essai sur l'Art de la Verrerie,* 80-86; de Fontenelle, *Manuel complet du verrier,* 170-172; Bontemps, *Guide du verrier*, 170.

[1124] Lefèbvre, *La verrerie à vitres,* 22; M. Cable, "The advance of glass technology in the nineteenth century," 117-118.

[1125] Christian Vandenbroeke, "De problematiek van de energievoorziening in de zuidelijke Nederlanden en inzonderheid in Vlaanderen," *Revue belge de philologie et d'histoire* 73, no. 4 (1995): 967-970.

[1126] Brigitte D'Hainaut, "Les combustibles utilisés dans l'industrie du verre au XVIIIème siècle," *Technologia Bruxellensis* 3 no. 4 (1980): 67-73.

[1127] ARA-Mines, nr. 776, dossier 712; nr. 778, dossier Verrerie Delobel

[1128] For example, ARA-Mines, cartes et plans, AK3662; AK3665 required 371 kg of coal. At the same time, according to the same authors, the total production cycle time increased from 24 hours in 1826 to 34–36 hours, making the work quite inconvenient.[1129] Hence, the energy efficiency as well as the 'work convenience' of glass melting declined while the production capacity increased.

The problem of energy efficiency had already been acknowledged in the middle of the 19th century, as attested by multiple invention patents dating from around 1850. Most of the patents attempted to improve fuel efficiency by improving the air and gas circulation within the furnace as well as by introducing some other small changes to the furnace design, such as the arrangement of pots within the furnace. Some patents even mention a sort of heat exchanger.[1130] One patent, registered in 1849, explicitly claimed that significant fuel economies could be made due to the better arrangement of pots in the furnace.[1131] Despite these efforts, the situation did not improve significantly, as fuel efficiency actually declined as described above.

In this context, several interesting foreign patents were registered in Belgium in the 1860s: two dating from 1860 and one from 1864. The two 1860 patents were *brevets d'importation*, while the 1864 patent was a Belgian *brevet d'invention* issued to a French citizen. These patents explicitly addressed the problem of considerable loss of time and fuel due to the discontinuous working of the existing furnaces. The proposed solution, found in all three patents, consisted of the division of the production process by the use of two furnaces: the *melting furnace* and the *working furnace*. As described above, the working process consisted of two steps – the melting and the 'working' (or processing, i.e. the gathering of glass mass for blowing) – which both happened within one furnace. By dividing these steps between two furnaces, the work could proceed continually. The country of origin of the two patents from 1860 is unclear, while the 1864 patent belonged to the French engineer François Aimé Maurice Hütter from the glass factory of Rive-de-Gier in the Loire.[1132] I have not found any sources indicating the practical implementation of this kind of technique in Belgium. At any rate, these patents indicate that the shortcomings of 'traditional' furnaces were acknowledged by 1860.

Regenerative furnaces

The solution for these problems would arrive two decades later, after a great deal of experimentation. It consisted of the combined application of two new principles: the use of gas fuel in combination with regenerators for heating instead of direct heating by coal; and the replacement of multiple pots by one large tank. Both principles were first invented around 1860 by the Siemens brothers, who were active in England and Germany. However, it took a lot of effort from Belgian engineers and industrialists to further develop and put into

[1129] Lefèbvre, *La verrerie à vitres,* 50-52; Drèze, *Le livre d'or de l'exposition de Charleroi en 1911*, 442; unfortunately, none of these authors quoted their sources; presumably, the numbers provided referred to the most common sizes of pots

[1130] ARA-2, brevets, brevet numéro indicateur 799 (1855); brevet numéro indicateur 825 (1855); brevet numéro indicateur 830 (1855); brevet numéro indicateur 974 (1855); brevet numéro indicateur 984 (1855); brevet numéro indicateur 991 (1855); brevet numéro indicateur 992 (1855); brevet numéro indicateur 1038 (1855); brevet numéro indicateur 1434 (1855); brevet numéro indicateur 1682 (1855)

[1131] ARA-2, brevets, brevet AC 4623 (numéro indicateur 5842) (1849)

[1132] ARA-2, brevets, brevet nr. 9118 (1860); brevet nr. 9502 (1860); brevet nr. 16573 (1864) practice these principles in Belgium, and even re-export them to foreign countries later. The technological transition occurred in two steps. First, *regenerative furnaces* were introduced; these used regenerators and gas producers, while still employing individual pots like the old traditional furnaces. After this, individual pots were replaced by one large continuously working tank in *tank furnaces*, that employed all three principles.

With the regenerative principle the heat of the exhaust gas was used to preheat the fuel gas and air before it was used for burning. This process took place in the so-called regenerators, i.e. heat exchangers constructed of refractory bricks. The fuel gas was created in the gas producers (also called gas generators), which transformed coal into gas by partial combustion with air. While the melting of glass still took place in individual pots, just like in old 'traditional' furnaces', the Siemens regenerative furnace thus combined two important technological innovations: the use of regenerators, and gas producers.[1133] Interestingly, the Siemens brothers first tried to build a regenerative furnace for steelmaking back in the 1850s, building first regenerative furnace for steelmaking in Sheffield and Wednesbury in 1857. However, after unsatisfactory results, the Siemens brothers abandoned their experiments with steelmaking regenerative furnaces in 1859, turning their attention to the regenerative furnaces for glassmaking instead.[1134]

Even so, the adoption of regenerative furnaces took place rather slowly in Belgium. The *Bennert & Bivort* glass factory started to use this type of furnace in 1867, but it took the firm years of experimentation to fully implement it. By 1881 this firm, which was one of the most innovative in Belgium, possessed 18 melting furnaces, nine of which were of the new type.[1135] The innovative efforts of Belgian industrialists in general were nevertheless acknowledged internationally. According to a report from the 1873 Vienna World Fair, the application of the Siemens regenerative furnace for window-glass production required important technical adaptations, mostly considering the distribution of flames within the furnace. As the report stated: 'The honour of greatest efforts in this direction [to solve this problem] is due to Belgium, and it can be stated, from now on, that a perfect success had been achieved.'[1136] Whether the 'perfect success' was an exaggeration or not, it is clear that Belgian industrialists (primarily *Bennert & Bivort*) played an important role in the development of the regenerative furnace technology, presenting proof of technological creativity.

In general, it was noted in the 1878 Charleroi Chamber of Commerce report that many manufacturers experimented with new heating systems for the melting and annealing of

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[1133] Chopinet, "Developments of Siemens regenerative and tank furnaces," 180-184; Chopinet, "The history of glass," 19-24; Cable, "The Development of Glass-melting Furnaces," 208-215; Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 52-54.
[1134] Cable, "The world's first successful regenerative furnace", 94-99; M. Cable, "The advance of glass technology in the nineteenth century," 118-122; Cable, "The Development of Glass-melting Furnaces," 208-215.
[1135] Drèze, *Le livre d'or de l'exposition de Charleroi*, 446; Archives Musée du Verre, Charleroi, Verreries Pays de Charleroi 18e-19e siècle ('Charleroi' box), nr. 8914/161/57, document Bennert & Bivort (11 juillet 1871), and nr. 8914/161/59, document Bennert Bivort (20 juillet 1871); "Les verreries Bennert & Bivort," in *L'indépendance belge*, 25 novembre 1897, p. 2
[1136] De Luynes, *Exposition universelle de Vienne en 1873,* 28. Quote: "C'est à la Belgique que revient l'honneur des plus grands efforts tentés dans cette voie, et l'on peut dire, dès à présent, que le succès parfait assuré"

glass in order to reduce fuel costs and to improve their competitive position on the market. No names or technical details were mentioned, however. It can nevertheless be assumed that the need (or even urge) to innovate was strongly felt within the community at that time.[1137]

Tank furnaces

The real breakthrough came only with the tank furnace after 1880. Unlike the older furnaces, that used multiple individual pots to melt the raw materials, the melting took place in one large tank in the tank furnaces. This allowed for a continuous production process. A curious testimony of an early attempt to build a tank furnace in Belgium is to be found in the *Association's* proceedings, which included a transcription of a eulogy in memory of Casimir Lambert (1827-1896), delivered in 1896 by Émile Fourcault. According to this source, Lambert tried to eliminate the use of individual pots back in 1864, when he started to conduct experiments with the 'melting of glass on the floor', the basic principle of a tank furnace according to Fourcault. However, 'civic duties' prevented Lambert from completing this project, and it was later conducted by Siemens who 'reaped the fame of an invention of which Lambert had thrown the seeds,' as formulated by Fourcault in the eulogy.[1138] Yet, no traces of Lambert's supposed invention are to be found in other sources, neither is any connection between Lambert and Siemens ever mentioned in the literature, so that the 'reaping' of fame must have been an exaggeration on the part of Fourcault. Hence, regardless of Lambert's early efforts, the first practical implementation of a tank furnace is to be attributed to Siemens.

Just like the regenerative furnace, the tank furnace was first invented in England by the Siemens brothers. The first commercial tank furnace was installed at the Pilkington factory in 1872. A lot of technical problems still remained, however. For instance, the materials of which the ovens were made wore out fast, limiting the lifespan of the first furnaces to just a few months. Moreover, the first tank furnaces were used for the production of bottle glass, which was easier to achieve as the production of bottles required the tank to be much less deep than for window glass.[1139]

The introduction of tank furnaces in Belgium can be credited to the engineer Martin-André Oppermann. As already mentioned, he had worked with William Siemens in England before settling in Charleroi circa 1874. Between 1874 and 1875, he conducted experiments with tank furnaces at his own expense. His main achievement was the adaptation of the tank furnace for window-glass production. Between 1876 and 1890, he worked as an engineer at the Jonet window-glass factory, where the first large tank furnace for window-glass production was installed under his supervision in 1877-1878.[1140]

[1137] *Rapport général de la chambre de commerce de Charleroi, sur l'état du commerce et de l'industrie dans l'arrondissement pendant l'année 1878*, 39.

[1138] Private archive Gobbe, Association, Originaux C, Assemblée Générale 30 novembre 1896

[1139] Chopinet, "Developments of Siemens regenerative and tank furnaces," 184-188; Chopinet, "The history of glass," 19-24; Cable, "The Development of Glass-melting Furnaces 1850-1950," 215-222.

[1140] "Un pionnier de la verrerie: l'ingénieur Oppermann," 5-6; *Journal de Charleroi* 9 février 1874 and 29 février 1920; Drèze, *Le livre d'or de l'exposition de Charleroi*, 450; Chambon, *Trois siècles de verrerie,* 42-44.

The Baudoux window-glass factory, established in 1881, was second to use tank furnaces in Belgium. Before starting his own factory, Eugène Baudoux had worked at the Jonet factory. We can assume that he learned the workings of a tank furnace there.[1141] Together with his engineer Jean-Matthieu Pagnoul, Baudoux had made numerous improvements to its construction. The greatest challenge in adapting the tank furnace for the production of window glass, as opposed to bottle glass, was the need for a much deeper glass bath. This depth depended on the permeability of glass to the heat. This permeability in turn depended on the glass composition, and hence on the sort of glass. For bottle glass, a bath depth of 30–40 cm was sufficient. For window glass, the depth required amounted to 1.5–2 metres, which came with tremendous technical difficulties. Baudoux and Pagnoul succeeded in resolving this problem. The construction of their first large tank furnace started in August 1884, and it was put into service around the new year change of 1884/1885. The colossal device employed 36 glassblowers, who gave it the nickname *Leviathan*. Encouraged by good results, Baudoux constructed a second tank furnace, which was put into use in September 1885.[1142]

Interestingly, there are indications that at least some other Belgian manufacturers had already started to use tank furnaces at the same time or only shortly after Baudoux. For instance, during the discussion of a *chômage* arrangement at the *Association's* meeting in June 1883, Lambert directed the *Association's* attention to the question of how tank furnaces would be integrated within the *chômage* system. Upon discussion, it was decided that a tank furnace would count for two ordinary furnaces, as it had a double production capacity when compared with pot furnaces.[1143]

The final improvements to the tank furnace in Belgium were made by Émile Gobbe (originally from France) when he settled in Jumet near Charleroi in 1890. With Pagnoul as a partner, he established a firm that came to play an important role on the world market of tank furnaces. Around 1896, there were two major players on this market: Siemens in England and *Gobbe & Pagnoul* in Belgium. *Gobbe & Pagnoul* dominated the world market with two thirds of all tank furnaces in the world were of their signature, according to Damour in 1896. They were especially successful in the United States, where they delivered the majority of all tank furnaces. *Gobbe & Pagnoul* was a study office rather than a production company. The physical construction was undertaken by specialised contractors, who worked under the supervision of *Gobbe & Pagnoul*.[1144] An advertisement published in a Belgian newspaper in 1895 lists various clients of *Gobbe & Pagnoul* in the United States, including *Chambers Glass Company* (Kensington, Pennsylvania) and *Thomas Wightman Glass Company* (Pittsburgh).[1145]

Generally, the tank furnaces constructed by Gobbe were 25 metres long and 3.5 metres wide, while the depth of molten glass amounted to 2-2,2 meter. The content reached 400

[1141] Chambon, *Trois siècles de verrerie,* 44.
[1142] Damour, "L'état actuel et les besoins de la verrerie et de la cristallerie en France," 138-139; Ph. Linet, "Eugène Baudoux," *L'encyclopédie contemporaine. Revue hebdomadaire universelle des sciences, des arts et de l'industrie* 2, no. 21 (15 January 1888): 1-3; *Moniteur industriel de Charleroi*, 4 janvier 1885
[1143] Private archive Gobbe, Association, Brouillons II, Séance 6 juin 1883
[1144] Damour, "L'état actuel et les besoins de la verrerie," 138-139; Chambon, *Trois siècles de verrerie,* 46.
[1145] *La revanche des verriers*, 15 mai 1895

tons of glass.[1146] Most tank furnaces in the Belgian window-glass industry made use of the Wilson gas producers, which added hot steam to the fuel gas in order to enrich it with hydrogen. As a result of this, the use of large steam boilers became widespread together with tank furnaces.[1147]

Figure 11: External view of a tank furnace

Source: © Musée du Verre, Charleroi

[1146] "Les fours à bassin dans les verreries," *La nature: revue des sciences et de leurs applications aux arts et à l'industrie* 1207 (18 July 1896): 106-108.
[1147] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre,* 52-53.

Figure 12: A battery of gas producers

Source: © Musée du Verre, Charleroi

The introduction of tank furnaces in the Belgian industry proceeded at a rapid pace in the second half of the 1880s and 1890s. By 1894, all Belgian window-glass factories used 32 tank furnaces. Only six pot furnaces remained in use at that time. They were exclusively used for the production of coloured glass and other special sorts of glass, whereby lesser quantities of glass melt were required. The introduction of the tank furnace significantly affected the Belgian window-glass industry in many ways. Because of the high cost of such an investment (approximately 250,000 Belgian francs[1148]), the number of glass factories declined sharply from 42 in 1870 to 24 in 1911, while total production increased. As the tank furnace allowed for a better (more regular) melting process due to continuous working when compared to the pot furnace, the quality of glass increased as well. Moreover, it allowed for the elimination of potters' workshops, thus cutting down on the labour costs.

The introduction of new furnaces was more a requirement than a choice, as the export focus of the Belgian window-glass industry meant permanent competition with manufacturers from other countries on the global market. In those circumstances, the ability to innovate was a 'must'.

During the 'American crisis' of 1884, the adoption of new technologies was explicitly mentioned by the *Association* as an important means towards the reduction of production costs alongside the lowering of glassblowers' wages and the reduction of customs and transport tariffs. As recorded explicitly in the *Association*'s report on the situation, the necessity for the manufacturers to lower the production price required them to examine

[1148] Delaet, "La mécanisation de la verrerie à vitres," 120.

improvements in the means of production. In particular, coal furnaces were replaced by gas furnaces, while tank furnaces, allowing for the continuous production, were in the experimental stage, with some 'serious progress' reported.[1149] Somewhat later, in 1885, the *Moniteur industriel* urged Belgian window-glass manufacturers to adopt new furnaces as fast as possible in order to address foreign competition.[1150] Yet, as already mentioned in the introductory part, the development of the tank furnace had a truly paradoxical effect on the international position of the Belgian window-glass industry. On the one hand, it was essential in order to compete on the international market; on the other, it was precisely because of the development of this technology that many foreign countries were able to develop their own window-glass industry, making international competition more intense.

The introduction of the tank furnace had a profound effect on labour in the glass factories. To begin with, it eliminated a whole range of specialised workers. Skilled potters were essential, as the making of pots for glass-melting required special know-how and tacit knowledge. Moreover, the operation of pot furnaces relied on a team of specialised workers known as *fondeurs*, *affineurs* and *tiseurs*. Their task was to maintain the right temperature during the cycle of glassmaking, from the first heating of a pot filled with raw materials to the final 'gathering' of molten glass mass from the pot by a glassblower and his assistants (*gamins*). With the introduction of the tank furnace, which worked continuously rather than in cycles, the operation became much easier, requiring less skill from furnace operators, while the need for pots (and hence potters) disappeared completely.[1151]

The impact of the tank furnace on the position of glassblowers is more debatable. A contemporary account by Ph. Linet published in 1888 stated explicitly that the tank furnace made the work of workers easier, threatening the position of master blowers, implying a certain de-skilling (albeit without explaining why and in what way).[1152] A contemporary monograph on the Belgian labour unions by Émile Vandervelde, published in 1891, noted that the tank furnace considerably facilitated apprenticeships, which could be considered as evidence of de-skilling as well.[1153] Later literature, such as works by Francis Poty and Jean-Louis Delaet (1986) and that of Gita Deneckere (2006) followed the same premise. According to them, it was easier to 'gather' glass from a tank furnace than from individual pots. This resulted in lower requirements with respect to the skillfulness of the glassblowers, allowing the employment of more and less-skilled apprentices and less fully trained 'senior' glassblowers, thus leading to a certain de-skilling. The great discontent on the part of the glassblowers, who feared for their privileged professional and social position, erupted in violence on 25-26 march 1886 (as a part of a broader 'social revolt'), when they burned down both the Baudoux factory and its mansion (Baudoux himself managed to escape).[1154] And yet, according to recent research by Widukind de Ridder (2011), the introduction of tank furnaces actually improved the position of glassblowers, while changing the labour

[1149] Private archive Gobbe, Association, Originaux C, Assemblée Générale 27 juillet 1885 – Rapport sur la situation en 1884

[1150] Engen, *Het glas in België,* 197; *Journal de Charleroi*, 21 février 1911; Drèze, *Le livre d'or de l'exposition de Charleroi*, 450; "Les fours à bassin dans les verreries" 106-108; *Moniteur Industriel de Charleroi*, 12 avril 1885

[1151] Drèze, *Le livre d'or de l'exposition de Charleroi,* 464.

[1152] Ph. Linet, "Eugène Baudoux," 1-3.

[1153] Vandervelde, *Enquête sur les associations professionnelles,* Vol. I, 113.

[1154] Deneckere, *1900: België op het breukvlak van twee eeuwen*, 68-72; Poty and Delaet, *Charleroi pays verrier,* 78-85.

organisation (division of labour) significantly (more on this in the next paragraph). According to De Ridder, the violent outburst of 1886 was motivated by the conflicts arising from wage calculations, as the new labour organisation arising from the introduction of tank furnaces engendered new systems for the calculation of glassblowers' wages. While these changes were caused by the new technology, the outrage was not directed primarily against the new technology itself.[1155]

In general, the introduction of tank furnaces can be described as a truly revolutionary innovation. While the production process (glassblowing) remained manual, the industry could no longer be described as 'traditional' (craft-like). Apart from furnaces, the adjacent equipment such as gas producers and large steam boilers transformed glass factories from relatively small workshops into large-scale industrial enterprises.

The development of the tank furnace was not an exclusively Belgian innovation, as it was being pursued at the same time in other countries as well, most notably by Siemens.[1156] The existing literature on the development of regenerative and tank furnaces by Siemens does not mention any influence from developments in Belgium. Yet, after the initial introduction of this concept in Belgium, further improvement was carried out, mostly autonomously, by various engineers and entrepreneurs there (Oppermann, Baudoux, Gobbe & Pangoul) in a successive, almost 'relay race-like' way. It is therefore a fine example of a development of innovation by means of a series of micro-inventions (or 'midi-inventions') leading to a major technological breakthrough. The new tank furnaces allowed for drastic savings in fuel. Whereas in 1873, 360 kg of coal was needed to produce a standard package of one hundred French square feet of glass, by 1910 coal consumption had been reduced to 120 kg only.[1157]

Glassblowing

Traditional working methods and craftsmanship

The second step in the production of any type of glassware after the melting of raw materials in melting furnaces, is the shaping of glass mass into the required form. In the case of window glass, manual glass blowing remained the dominant technique until the First World War. Two methods of producing flat window glass were known from the Middle Ages: the crown glass method and the cylinder method (also known as 'broad glass' in England).[1158] As the crown glass method was no longer used in 19th-century Belgium, it will not be discussed further here. As already mentioned in the introductory part, the cylinder method was introduced in present-day Belgium by migrant glassblowers from Southern Germany and Alsace (and, possibly Lorraine) in the 17th and especially 18th century.

In very basic terms, the method consisted of blowing a huge glass cylinder that was cut and flattened to obtain a sheet of flat glass. The process of cylinder-blowing consisted of three steps, the 'gathering' (*cueillage*), the 'blowing' (*soufflage*) and the 'elongation' (*longeage*). In the early 20th century, a team consisted of one (senior) glassblower, assisted by two

[1155] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 125-130.
[1156] Cable, "The Development of Glass-melting Furnaces 1850-1950," 212-219.
[1157] Douxchamps, "L'évolution séculaire de l'industrie du verre à vitres," 481.
[1158] Cable, "The Development of Flat Glass Manufacturing Process," 20-23.

assistants, called first *gamin* and second *gamin*. While every senior glassblowers passed through the stadium of *gamin* in the course of his apprenticeship, not every *gamin* succeeded in becoming a senior glassblower. Hence, *gamin* should not necessarily be seen as a synonym of apprentice. It should be noted that the glassblowers' assistants were often called *cueilleurs*. In most cases, the terms *gamin* and *cueilleur* were used as synonyms, although sometimes a distinction was made. The exact meaning of this distinction is unclear.[1159]

The work on a new cylinder was initiated by the second *gamin* who 'gathered' molten glass with the cane multiple times, in order to make a bubble of glass (*paraison*) which was large enough, applying multiple layers of glass. After this, he passed the cane with *paraison* to the first *gamin*, who conducted the last *cueillage*, applying the last layer of glass on the *paraison*. Then, the first *gamin* re-heated the *paraison* in the glory hole of the furnace and placed it into the *bloc de souffleur*, a kind of mould made of wood (beech in most cases) in order to give the *paraison* the required diameter. After this, he passed the cane with the *paraison* to the glassblower, who further blew it to greater dimensions. In order to turn the somewhat pear-shaped *paraison* into a true cylinder (that is, to elongate it, hence *longeage*), the glassblower swung the cane in a special 'trench' (*fosse*) in the factory floor. The *fosse* itself was four metres deep, yet the glassblower stood on a raised floor of one metre, hence having a space of five metres for the *longeage*.[1160]

[1159] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 111.
[1160] Poty and Delaet, *Charleroi pays verrier,* 128-140; Stéphane Palaude and Catherine Thomas, *La verrerie, une ruche humaine? Le cas de la région de Charleroi, de la belle époque aux années folles (1880-1930)* (Charleroi: Musée du Verre de Charleroi, 2018): 40-43.

Figure 13: Blowing of glass cylinders. Longeage on the left (note the fosse), preparation of a paraison on the right

Source: © Musée du Verre, Charleroi

Although the basic process remained unchanged throughout the 19th century, small improvements could prove surprisingly efficient. Between 1822 and 1867 various equipment pieces were developed, that helped to support the glassblower's cane, thus allowing him to produce larger cylinders. These equipment pieces are known as *lanceman* (introduced in 1822-1823), *crochet d'ouvreau* (introduced in 1845) and *manique* (introduced in 1867).[1161] A report on the state of the Belgian window-glass industry, published in the Official Journal of the French Republic in 1872, mentioned a kind of mobile support for the glassblower's cane that was mounted on a small rail cart. It is possible that various systems of supports for a glassblower's cane were used in Belgium at that time. At any rate, according to contemporaries, these seemingly trivial innovations allowed for 'great progress' in window-glass production, as they facilitated the production of larger sheets of window glass.[1162] Because of these improvements, the maximum size of glass sheets would have evolved from 49 x 38 cm in 1820 to 130 x 86.5 cm in 1870 according to Lefèbvre (1938).[1163] These dimensions should not be taken as absolute, but rather as the most common regular sizes. To put it another way, they are indicative of general trends of product improvement by means of 'trivial' micro-inventions (see Chapter 3.4 on the qualities and properties of glass further for more details).

Unfortunately, the origin of these 'trivial' yet important innovations is mostly unknown. It cannot be ruled out that they were imported from other countries. Yet, as was attested by the aforementioned French report, the adaptation of these devices was perceived as an important advantage of the Belgian window-glass industry. As already mentioned, between approximately 1870 and 1890, various 'trivial' inventions were registered by means of patents, that concerned various tools and equipment pieces (such as levers, *maniques*, etc.), that were intended to lighten the glassblower's work.[1164] It is impossible to know the degree to which they all were implemented, and whether they were truly original compared to foreign practices, but it is indicative of a constant search to improve work efficiency, and, in other words, of technological creativity.

Unfortunately, information on the organisation of labour on the work floor is very scarce. Writing in 1868, Bontemps described a 'typically Belgian' way of working, which was already quite similar to the way of working practised in the early 20th century, as discussed at the beginning of this paragraph. By having a glassblower assisted by two *gamins*, a certain amount of the division of labour was achieved, allowing for faster production. Although Bontemps does not mention an exact date (neither is it clear in what way this new method of work differed from the old), it follows from his description and wording that this way of working was relatively new.[1165] According to Daniel Massart, the position of second *gamin* was introduced circa 1870 when, due to the increasing size of pots, the workload increased to such an extent that one *gamin* was no longer enough.[1166] Presumably, Bontemps alluded to the addition of one extra gamin to the team as the 'typically Belgian' way of working.

[1161] Lefèbvre, *La verrerie à vitres,* 52-54; Engen, *Het glas in België,* 195.
[1162] *Journal officiel de la république française*, 9 décembre 1872, 7634-7636.
[1163] Lefèbvre, *La verrerie à vitres,* 52-54; Engen, *Het glas in België,* 195.
[1164] ARA-2, brevets, brevet nr. 27088 (1870); brevet nr. 28187 (1870); brevet nr. 89946 (1890)
[1165] Bontemps, *Guide du verrier,* 273-274, Quote: "Les verreries belges ont introduit une modification qui accélère l'épuisement des pots…"
[1166] Massart, *Verreries et verriers du Centre*, 27.

Thus, alongside new tools, some innovations with regard to the organisation of labour were taking place as well.

The introduction of the tank furnace changed the organisation of labour significantly, as discussed by de Ridder. As the production process became continuous rather than cyclical, shift work with set hours was introduced.[1167] Before that, the work occurred in cycles, starting from the heating of pots with raw materials and ending when all glass mass from a pot was used. Depending on the size of pot, such a cycle could take up to 24 hours, of which 10 to 12 hours of effective glassblowing (another 10 to 12 hours were taken by heating and melting), resulting in irregular work hours.[1168] Alongside shift work, long-term employment contracts (from three months to seven years, and in extreme cases even 13 years[1169]) and code of conduct were introduced.[1170] However, as will be discussed in the following section, the first *Réglement d'ordre intérieur* (code of conduct) was introduced already in 1875, which is before the introduction of the tank furnace.[1171] Nevertheless, these developments did not change the production method itself in any significant way. As already noted, according to de Ridder, no de-skilling of glassblowers occurred either.[1172]

The production of cylinder glass may seem like a quite straightforward and uncomplicated method, but the production of glass required exceptional skills. While glassblowing developed mainly outside of the craft guild organisation, some aspects remind us a little of guild-like conduct up to the beginning of the 20th century, at least according to the image found in the existing literature. According to the description provided by Jean-Louis Delaet, there was no formal vocational training for starters. Learning was conducted on the work floor in an informal way. Only close relatives (sons or nephews in most cases) of glassblowers were allowed to learn the craft. Quoting from an older work by E. Close (*Nos gentishommes verriers*, 1938), Delaet mentions a 'popular wisdom' adhered to by most glassblowers, stating that only those with 'the right blood' (*il fallait être de sang*) could become a glassblower. Apprenticeship took up to seven years.[1173] It is interesting to note that the seven-year apprenticeship was regarded as bearing an almost symbolic significance in many trades in England well into the 19th century.[1174] However, in the 1880s, employment terms of two or three years for apprentices were discussed within the *Association*.[1175] All in all, the process of skill acquisition by the apprentice glassblowers was reminiscent of the early modern craft practice, whereby skills were acquired on the work floor under the supervision of a master artisan according to the 'learning-by-doing' principle. From this perspective, the tacit knowledge of glassblowers could be characterised as 'artisanal knowledge'.[1176]

1167 de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 112.
1168 Poty and Delaet, *Charleroi pays verrier*, 63.
1169 de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 155.
1170 Ibidem, 112.
1171 Ibidem, 112.
1172 Ibidem, 125.
1173 Delaet, "La mécanisation de la verrerie à vitres," 125-126.
1174 Rule, "The Property of Skill in the Period of Manufacture," 100-101.
1175 Private archive Gobbe, Association, Brouillons II, Séance 7 avril 1884
1176 Bert De Munck, "Artisanal Knowledge and Craftsmanship," in: *Encyclopedia of Early Modern Philosophy and the Sciences*, eds. Dana Jalobeanu and Charles T. Wolfe (Cham: Springer, 2020): 121-131.

The symbolic property of skill was held in high esteem within the glassblowers' community. Delaet provides several popular stories, found in the local press, that portray glassblowers as very proud and materially affluent people. According to one of these stories quoted by Delaet, one glassblower paid a band of accordion players to accompany him on his daily journey to the factory. Another one would use banknotes to light his cigars. Even if these stories weren't true, they clearly indicate that glassblowers were perceived as enjoying a certain social standing and wealth, with both their pride and their wealth dependent on their exceptional skills.[1177] It is therefore not surprising that they were aware of the social distinction between themselves and other glass workers, known as 'cold workers' (glass cutters, packagers, etc.). In 1846, for instance, the glassblowers of the *Verreries de Mariemont* factory resolutely refused to contribute to mutual aid together with other workers.[1178] Clearly, they regarded themselves as a special kind of worker, quite distinct from proletarians. Later, the glassblowers' union (*Nouvelle Union Verrière*, established in 1894) explicitly excluded 'cold workers' from participation (they had their own unions).[1179]

This attitude of the Belgian window-glass blowers was by no means unique, as attested by John Rule. The sense of the 'property of skill' ('owning a skill' as a means of social distinction) was deeply embedded in the mentality and culture of artisans within many trades until at least the early 19th century.[1180] Nevertheless, it seems to have lasted longer in this industry than in many others, which can arguably be attributed to the lack of mechanisation of the crucial production step (which, as we argue in this chapter, should not be taken as a lack of innovation altogether).

The tacit knowledge and craftsmanship of glassblowers were extremely important for the industry. Unfortunately, the content of this knowledge is largely unknown to us. On the one hand, as the training remained largely informal, very little has ever been recorded. On the other, the famous assertion that 'we can know more than we can tell' by Polanyi is very true in this case. Still, we possess indirect indications of the value of the glassblower's tacit knowledge. The wages are one of the best indicators in this respect. In 1846, glassblowers earned the highest wages of all Belgian industrial workers. An average daily wage in glass factories amounted to 2.58 francs, while in coal mines it amounted to only 2.07 and in linen to 0.80 francs. In particular, the best glassblowers at the Mariemont glass factory earned 400 francs a month in 1846. Given that the average daily wage in the Belgian industry amounted to 1.49 francs, we can conclude that at least some glassblowers used to earn tenfold the average wage. By 1891, glassblowers earned a day wage of 15–17.5 francs, while woollen weavers, for example, had to be satisfied with a daily wage of three francs.[1181]

And yet, despite the aforementioned anecdotal evidence, as well as more 'objective' indications such as the wages, there are indications that the property of skill of glassblowers was less 'unproblematic' (uncontested and accepted) than may appear from the existing literature. A study of the *Association*'s proceedings, as well as some other sources and more recent work by De Ridder, indicate that this property was under constant pressure on the

[1177] Delaet, "La mécanisation de la verrerie à vitres," 126-127
[1178] ARA-Mines, nr. 778, dossier 1665
[1179] Poty and Delaet, *Charleroi pays verrier,* 97-99.
[1180] Rule, "The Property of Skill in the Period of Manufacture," 99-102.
[1181] Olyslager, *De localisering van de Belgische nijverheid*, 146; AGR-Mines, nr. 778, dossier 1665

part of manufacturers throughout the 19th century, as will be shown in the following paragraphs.

Property of skill

The question of the relationship between glassblowers and industrialists should be addressed here as well, even if it goes beyond the topic of craft skill itself in the narrow sense. Indeed, as manual skill remained of key importance for the entire production process, it is important to understand who controlled or even 'owned' this skill. As appears from the stories and popular wisdoms mentioned previously, glassblowers literally claimed the ownership of their skill. This image also emerges from the older literature as well, such as the aforementioned work by Delaet.[1182] Nevertheless, as appears from the *Association*'s proceedings as well as some other sources, the control of this property of skill had been the subject of a struggle between factory owners and glassblowers already from the early 19th century on.

As noted above, traditionally, the craft of glassblower had been transmitted within families from father to son. As discussed by Delaet, this system was known as 'workers of blood' (*ouvriers du sang*). Hence, the glassblowers themselves, and not the factory owners, had the control over the training of new glassblowers, who started as *gamins* (assistants-apprentices) at the age of 8-10 years. However, due to the growth of production from approximately 1845 on, the system of 'workers of blood' increasingly came under pressure. Increasingly, manufacturers started to employ apprentices that did not have the 'right blood'.[1183]

In fact, there are indications that the 'workers of blood' system came under pressure even earlier. Léopold de Dorlodot, one of the important glass manufacturers of Charleroi, claimed to have started employing 'bastard glassblowers' (*souffleurs bâtards*), who were not 'workers of blood', in 1826 already. If we are to believe his words, other manufacturers of the region soon followed his example.[1184]

Undoubtedly, the control of vocational training and apprenticeship can be regarded as an important part of the property of skill. According to de Ridder, the apprenticeship system continued to be controlled by the glassblowers (and not the bosses) in 1872.[1185] However, the *Association's* proceedings show that the bosses at least had some influence in these matters, as the control of the labour force, including apprenticeship, emerged within the proceedings from the early 1850s already. In 1853, the *Association* decided that each manufacturer should have the right to 'make' (most probably, to control and train apprentices) as many glassblowers as he considered necessary.[1186] The *Association* even proposed jointly leasing a glass factory to use it as a vocational school in case the efforts of

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[1182] Delaet, "La mécanisation de la verrerie à vitres," 125-126.
[1183] Poty and Delaet, *Charleroi pays verrier*, 74-92.
[1184] Autobiographical manuscript by Léopold De Dorlodot, original preserved in the private archives of the De Dorlodot family, reproduced in Belvaux, *La famille (de) Dorlodot*, vol. 1, 288-289.
[1185] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 104-105.
[1186] Private archive Gobbe, Association, Originaux A, Séance 18 mai 1853, quote: "Tout fabricant aura le droit de faire tant de souffleurs qu'il jugera convenable"

individual manufacturers proved insufficient to relieve the shortage of glassblowers.[1187] Yet no further mention of this initiative can be found within the proceedings, suggesting that the 'vocational school' never came into being. In the following years, the 'making' of glassblowers (*souffleurs*) or assistant-apprentices (*gamins*) by glass manufacturers appeared multiple times in the *Association's* proceedings. For example, in 1863 *Bennert & Bivort* were asked by the *Association's* representatives whether their firm would join the agreement for the 'making of *gamins*'.[1188] Although there are no further details concerning this agreement, this instance indicates implicitly that the *Association* tried to have an impact on collective arrangements regarding the vocational training of *gamins*. Much later, in 1881, it was again proposed to use inactive furnaces for the training of new labourers, almost in the manner of an improvised trade school. This proposal seems not to have gained the *Association's* support,[1189] but these examples nevertheless illustrate the *Association*'s attempts to control skilled workers, which makes sense as their skills could certainly be seen as a major resource in the district.

The relationship between glassblowers and *gamins* was addressed on several occasions as well. On one such occasion in 1874, the President remarked that it would be better not to interfere in the relationship between glassblowers and *gamins*. This remark was made as a reaction to the proposition for the establishment of a set tariff for *gamins*.[1190] This brief remark is telling, as it makes clear that glassblowers still held their autonomy, at least concerning the relationship with their *gamins* (assistants-apprentices), financial questions included. Interestingly, at the subsequent meeting, the President remarked that the glassblowers 'did nothing to stimulate *gamins*'.[1191] Possibly, this remark referred to the 'making of *gamins*'.

The urge to 'make' *gamins* and other workers reappeared on multiple occasions afterwards as well. For example, speaking in 1876, the President of the *Association* reminded its members of their commitment to 'make' as many *gamins* as possible.[1192] It appears therefore that the practical vocational training was at least partly organised and controlled by industrialists themselves in their factories. Paradoxically, the *Association* urged its members to 'make workers' even at moments of overproduction, when, logically, the workforce should have been redundant rather than in short supply, such as had been the case in early 1878, as attested in the proceedings. Nevertheless, the perspective of economic recovery made the *Association* fear the possible future situation whereby manufacturers would literally 'steal' workers from each other.[1193] Moreover, the recovery would cause labourers' wages to increase again. This 'deplorable' outcome could only be avoided by 'making' new labourers during crisis periods, according to the *Association*.[1194]

In 1875, the *Association* adopted a common *Réglement d'ordre intérieur* (code of conduct) for all participating firms, which is indicative of both the improved cooperation between

[1187] Private archive Gobbe, Association, Originaux A, Séance 18 mai 1853
[1188] Private archive Gobbe, Association, Originaux A, Séance 7 juin 1863
[1189] Private archive Gobbe, Association, Originaux C, Séance 8 août 1881
[1190] Private archive Gobbe, Association, Brouillons I, Séance 22 septembre 1874
[1191] Private archive Gobbe, Association, Brouillons I, Séance 3 novembre 1874
[1192] Private archive Gobbe, Association, Originaux C, Séance 12 janvier 1876
[1193] Private archive Gobbe, Association, Originaux C, Séance 18 janvier 1878
[1194] Private archive Gobbe, Association, Originaux C, Séance 11 février 1878

manufacturers in order to better control the workforce and the imposition of tighter discipline upon workers. The code delegated an important role to the representative of the factory owner, called *employé* (apparently, a kind of foreman), who had to intervene and provide command over workers in case the normal course of business was disrupted for one reason or another. Even the glassblowers themselves, who had traditionally been described as semi-autonomous and organising their work largely themselves, had to follow instructions given by the *employé*.[1195] The term *employé* itself is of interest, as it points to the position of this functionary as fully employed by the firm, as opposed to the special position of glassblowers and *gamins*, who still enjoyed some autonomy versus management, as will be shown later.

The role of the foreman increased after the introduction of the tank furnace, which implied tighter labour organisation. From that moment on, foremen assigned work posts to glassblowers and controlled their work in other ways. According to De Ridder, this effectively signalled the end of the glassblowers' autonomy on the work floor.[1196] The foremen also kept track of working days performed by glassblowers, which gave them power too. Interestingly, De Ridder uses the term *facteur* to refer to foremen rather than *employé*, as recorded in the *Association's* proceedings earlier.[1197]

The *Réglement d'ordre intérieur* defined the work relations between glassblowers and their *gamins* as well. According to the stipulation, each glassblower had to appoint and pay for his *gamin* himself. This kind of subcontracting arrangement, was typical of many traditional industries. Moreover, it attested to the remaining autonomy of glassblowers. Yet, at the same time, the *Réglement* postulated that the choice of *gamin* by the glassblower had to be approved by the factory director. Moreover, the factory director retained the right to fire a *gamin*. Hence, it can be concluded that the factory owners at least endeavoured to limit the traditional autonomy of glassblowers, although it remains unknown to what degree these regulations were observed in practice.[1198]

Due to the *Association's* measures, the bosses' control over the apprenticeship of *gamins* increased further by the last quarter of the 19th century. For instance, in 1881 it was decided that every member of the *Association* would employ two *gamin*-apprentices of 14 years old or younger at every active furnace. The lists of *gamin*-apprentices were to be supplied by all members to the *Association*.[1199]

As already discussed in Part 2, Chapter 2.2 on the *Association* (the paragraph on the *Association* and labour movement), the practice of 'two for one', whereby two glassblowers occupied one work post, was the subject of a struggle between the *Association* and the glassblowers' union around 1884. Although the exact outcome of the struggle is unclear (the question simply disappears from the proceedings), the issue itself is noteworthy, as it indicates the degree of workplace autonomy glassblowers still possessed at that time.

[1195] Private archive Gobbe, Association, Originaux C, Séance 5 février 1875
[1196] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 150-155, 170-174.
[1197] Ibidem, 162.
[1198] Private archive Gobbe, Association, Originaux C, Séance 5 février 1875
[1199] Private archive Gobbe, Association, Originaux C, Séance 17 mai 1881

Apparently, the labourers wanted to choose their substitutes themselves, while the *Association* wanted to abolish this practice.[1200]

The 'making of apprentices' came to the fore again during the 'American crisis' of 1884. At the meeting of 24 March 1884, the President encouraged *Association* members to 'make' apprentices. Responding to this proposition, Gregorius, one of the *Association's* members, responded that he had shut down two furnaces in order to lower workers' wages. Misonne, another member, reacted by saying that he would put two furnaces back in service with apprentices 'if he could find the necessary resources'. In broad lines, the source of the conflict between the *Association* and the *Union Verrière* at that moment can be described as follows. The manufacturers decided to diminish production (as a reaction to the overproduction crisis), causing unemployment. Hence, the *Union* wished to alleviate the unemployment (or even to create an 'artificial labour shortage') by insisting on the 'two for one system'. Apparently, manufacturers regarded apprentices as potential strike breakers.[1201]

More discussions on the organisation of apprenticeship followed, as it was discussed whether the apprentice-glassblowers and *gamins* (interestingly, these categories were regarded as distinct at that moment) should be hired for a term of two or three years. According to Bastin, one of the *Association* members, it would be in the worker's own interest to use the term of three years instead of two. This proposition was adopted by majority vote.[1202] Please note that this term is quite distinct from the apprenticeship of seven years that is mentioned in the existing literature (Delaet, 1986).[1203]

A practice somewhat similar to the old 'two-for-one' arrangement, known as *doubleurs*, was mentioned in 1904. Apparently, this referred to the practice whereby workers sometimes had themselves replaced for a period of time, possibly without the factory owner's permission. However, this practice was eliminated by the application of a *convention d'apprentissage* of 1904. This *convention* included conditions for the organisation of apprenticeship of various categories of workers (not exclusively glassblowers and *gamins*). It defined the number of apprentices each manufacturer should 'form', namely one *gamin*, one second *gamin* and one glassblower per three annealers. It is quite interesting to note that *gamins* and glassblowers apprentices were implicitly regraded as distinct categories there. Traditionally, *gamins* were regarded as glassblower-apprentices and assistants. While not every *gamin* would eventually become a glassblower (many remained as an assistant for their whole career), every glassblower passed through the *gamin* phase in the course of his professional development before becoming a senior glassblower. In this case, however, it rather seems that *gamins* and glassblowers were regarded as different categories of workers from the beginning of their apprenticeship on. While apprentice-glassblowers would become senior glassblowers eventually, the apprentice-*gamins* were intended to remain assistants. Speculatively, this development was connected to the changes in the work organisation (such as the distribution of tasks), possibly connected to the introduction of tank furnaces and the

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[1200] Private archive Gobbe, Association, Originaux C, Assemblée Générale 27 juillet 1885 – Rapport sur la situation en 1884

[1201] Private archive Gobbe, Association, Brouillons II, Séance 24 mars 1884

[1202] Private archive Gobbe, Association, Brouillons II, Séance 7 april 1884

[1203] Delaet, "La mécanisation de la verrerie à vitres," 125-126.

more 'assembly-line' way of working related to it. Yet, due to the lack of sources on the organisation of the work process in practice this cannot be more than a hypothesis.

Furthermore, the conditions of the *convention d'apprentissage* set the minimal contract length for the apprentices (glassblowers as well as *étendeurs* – annealer operators and glass cutters) at three years only. This is contrary to the traditional view of the required apprenticeship time of seven years for glassblowers. Moreover, it even contradicts the factory owners' own claims that the industry could not function without child labour, as the long apprenticeship time needed to train a glassblower made it necessary to start at an early age. This will be discussed in the following paragraph.[1204]

The *Association*'s proceedings hence attest that the *Association* attempted to acquire a greater degree of control over the apprenticeship system in the last quarter of the 19th century. At the same time, according to Widukind De Ridder and Ad Knotter, the system was still controlled by the *Nouvelle Union Verrière*. Knotter in particular mentioned that only *ouvriers du sang* were allowed to take part in the apprenticeship.[1205] Both authors based this claim on the contemporary monograph on the Belgian labour unions by Émile Vandervelde (1866–1933), a prominent Belgian socialist politician at the time.[1206] In it, Vandervelde provided extracts from the *Nouvelle Union Verrière*'s regulations, in particular considering apprenticeship. Therein, the conditions for apprenticeship were described as follows: 'Every person wishing to "make" an apprentice, will submit a written request to the assembly. If the request is approved, the apprentice can only take place if he has a letter of recommendation from 'T.C.' (not clear what 'T. C.' meant). However, the latter will only grant it to him when he has recognized that the aforementioned apprentice has acquired capacities necessary of the trade.'[1207] It thus appears that individual glassblowers chose their own apprentices, while this choice had to be approved by the union.

It is therefore difficult to draw a clear conclusion about who (the entrepreneurs represented by the *Association,* or the workers represented by the *Nouvelle Union Verrière*) truly 'owned' the glassblowers' skill by controlling the apprenticeship. On the one hand, the *Association's* proceedings attest that the *Association* attempted to increase control over the apprenticeship in the last quarter of the 19th century, discussing the 'making' of apprentices and setting various conditions for the apprenticeship. On the other hand, as appears from Vandervelde's monograph, the *Nouvelle Union Verrière* still acted as a gatekeeper to the trade of glassblower, deciding who could become an apprentice, and hence controlling the supply of the labour force. As noted by de Ridder, all recruitments went through the *Nouvelle Union Verrière*,[1208] In this way, the *Union* acted as a typical craft union, using the apprenticeship system as a tool for regulating the supply of labour to the craft, and,

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[1204] De Leener, *L'organisation syndicale des chefs d'industrie,* vol. 1 les faits, p. 227-241.

[1205] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 122-123; Knotter, "Trade unions and workplace organization," 423.

[1206] Vandervelde, *Enquête sur les associations professionnelles*, Vol. I, 111-128, Vol. II, 40-43.

[1207] Ibidem*,* Vol. II, p. 115. Quote: "Toute personne désireuse de faire un apprenti, en fera la demande par écrit à l'assemblée. Si la demande est agréée, l'apprenti ne pourra prendre place que lorsqu'il sera muni d'une lettre de recommandation de "T. et C.". Toutefois, ce dernier ne la lui accordera que lorsqu'il aura reconnu que le susdit apprenti a acquis la capacité nécessaire au métier qu'il embrasse"

[1208] de Ridder, "Loonsystemen, Arbeidsorganisatie en Arbeidsverhoudingen," 121, 203-204.

consequently, exercising control of wages as well.[1209] In any rate, no mention of *ouvriers du sang* was recorded in the apprenticeship conditions (at least not in the extracts quoted by Vandervelde), making it at least plausible that by the late 19th century this condition was no longer being requested.

In conclusion, it can only be stated that both parties, the *Association* as well as the *Nouvelle Union Verrière*, played their part in the 'ownership of skill'. Unfortunately, the source situation does not allow us to draw a more decisive conclusion.

Social legislation and child labour

A new chapter in the relationship between factory owners and labourers, as well as the organisation of labour and, ultimately, of the entire production system, began in the late 1880s in the context of the social turmoil of the late 19th-early 20th century. The role of craftsmanship (especially, apprenticeship), which is the topic of the present section, was important in these matters, and therefore the discussion of this social history is relevant here as well.

As noted in the Part 1, Chapter 1.4, the entire industrial region of Liège and Charleroi experienced a series of violent strikes in March 1886, known as the 'social revolt'. While this revolt was a largely spontaneous and 'leaderless' outburst without the direct aim of influencing national politics and legislation, it definitively influenced politicians' minds in parliament and government in Brussels, putting the social questions high on the political agenda. Ultimately, this resulted in the development of social legislation, although the traditional liberal and non-interventionist attitude of the Belgian political establishment slowed the process down. In particular, the first law on child and female labour was adopted in 1889 (*Loi concernant le travail des femmes, des adolescents et des enfants dans les établissements industriels* of 13 December 1889). According to this law, industrial labour was forbidden for children under 12. For boys between 12 and 16 and girls between 12 and 21, the maximum length of the workday was set at twelve hours (with one break of an hour and a half), while night labour (defined as labour between 9 p.m. and 5 a.m.) was prohibited for adolescents under 16, and one day off per week (not necessarily Sunday) was mandatory. However, certain industries were granted an exemption, allowing night labour for children between 14 and 16. The glass factories (*verreries*) were among these exceptions, so the law of 1889 'generously' allowed children from 14 years old on to work at night.[1210]

In the longer run, the introduction of social laws occurred in two waves before 1914, that is around 1886-1889 and 1900-1910. These laws were related to the regulation and, in some cases, ban on child and female labour, control on labour conditions by public authorities, and the introduction of social funds for labour accidents, illness, and so forth. These were not to the employers' liking, and they often expressed their indignation at these social measures.[1211]

[1209] Jack Barbash, "Union Interests in Apprenticeship and Other Training Forms," *The Journal of Human Resources* 3, no. 1 (winter 1968): 71-75.

[1210] Deneckere, *1900 België op het breukvlak van twee eeuwen*, 68-75, 129-130; "La législation protectrice en Belgique," 432-433.

[1211] Vanthemsche, *De paradoxen van de staat*, 103.

The introduction of these laws was regarded as a very serious threat by the *Association*. Already in 1888, Jonet (no first name mentioned) drew the *Association*'s attention to a new law-in-the-making that would forbid night labour for children. It was regarded as harmful for the glass industry, concerning the employment of children for glassblowing and annealing in particular. The *Association* President proposed drawing up a petition against the law.[1212]

The question of child night labour in particular remained on the *Association*'s agenda for many years even after the introduction of the first social laws and regardless of the exemption provided for the glass industry by the 1889 law. Already in early 1893, the *Association* wanted to file a petition for the revision of the law in order to allow night labour for children of 12 years old.[1213] In 1895, the *Association* sent a delegation consisting of L. Lambert, P. Noblet, L. Monnoyer, and F. Gobbe to negotiate with the Minister of Labour about the possibility of lowering the minimum age for night labour for boys to 13 years.[1214]

Apparently, this demand was not granted by the government. Reacting to this, the *Association* refused to respect the law on child labour, declaring that the law 'was impossible to implement'.[1215] In February 1896, the *Association* formally decided to 'refuse to provide information from the manufacturers' wages' accounts books' to the labours inspectors (*inspecteur du travail*) who oversaw the implementation of the law of 13 December 1889.[1216] Also in 1896, the President informed the *Association* of a possible revision of the law on female and child labour 'in a sense desired by the glass industry', that is, the permission to employ children of 12 years old. Being somewhat optimistic in this respect, he announced a new petition to the government for the revision of the law.[1217] The issue seems to have reached its zenith in 1898, when the *Association* decided not even to try to hide the instances of child night labour, but, on the contrary, to actively show violations of the law to the labour inspectors. By openly sabotaging the law in this way, the *Association* aimed to make it clear that the industry could not function without child labour. At the same time, it decided to address a new petition to the Minister, demanding the establishment of the minimum age for night work for children at 12 years old.[1218]

As appears from the proceedings of 1908, by that time the government had enforced the law with a 'toleration policy', allowing the employment of children from the age of 13, instead of the minimal age of 14, as prescribed by the law.[1219] This could have been a result of actions by the *Association*.

Child labour remained a point of conflict up until the outbreak of the First World War, as the factory owners considered it absolutely essential, therefore trying to thwart the emerging social legislation by all means possible. Even as late as 1913, the *Association* still proclaimed

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[1212] Private archive Gobbe, Association, Brouillons II, Séance 31 août 1888
[1213] Private archive Gobbe, Association, Brouillons III, Séance 3 janvier 1893
[1214] Private archive Gobbe, Association, Originaux C, Assemblée Générale 22 mars 1895
[1215] Private archive Gobbe, Association, Originaux C, Assemblée Générale 13 septembre 1895
[1216] Private archive Gobbe, Association, Originaux C, Assemblée Générale 4 février 1896
[1217] Private archive Gobbe, Association, Originaux C, Assemblée Générale 6 juillet 1896
[1218] Private archive Gobbe, Association, Originaux C, Assemblée Générale 25 février 1898, Assemblée Générale 8 avril 1898
[1219] Private archive Gobbe, Association, Originaux D, Assemblée Générale du 21 décembre 1908

that ‘all efforts of industrialists should be directed towards the maintenance of 12 years as the minimal age for employment of young labourers in the glass industry’. To achieve these ends, it tried to engage in negotiations with the Belgian government.[1220]

The last strategy, proposed shortly before 1914, consisted in disguising child labour as ‘vocational education’ (*enseignement professionnel*), which had to be conducted on the factory floor. If we are to sum up the general argument for the preservation of child labour, as formulated within the *Association* more or less explicitly on various occasions, it would read as follows: ‘In order to get well-skilled glassblowers, you should start learning (by doing) early enough, therefore, child labour is essential for the survival of the industry’. Here, child labour (under 14 years old) during day and night hours was explicitly mentioned.[1221] The ‘necessity’ for night child labour, while not being stated explicitly, must have been motivated by the continuous production in the window-glass industry, i.e. it did not stop during the night. The emphasis on night labour suggests that, despite its claims, the *Association* saw children primarily as a workforce rather than ‘vocational students’. Arguably, the *Association* wanted to employ children as assistants that worked the same hours as other workers. On the other hand, ‘vocational training’ could hardly justify night work, as learning could be limited to daytime hours.

The *Association* even took the anti-social-legislation lobbying up to the international level, when they participated in the 1913 Berne conference on labour legislation, one of the three conferences organised by the *International Association for Labour Legislation* in this Swiss city in 1905, 1906 and 1913.[1222] The International Association for Labour Legislation was founded in 1900 in Paris, and its main task was to improve the employment conditions of workers in general.[1223] Yet the *Association* used this opportunity to the exact opposite ends, that is, to thwart the development of social legislation, in particular concerning night and child labour.

The 1913 Berne conference, which was held on 15 September, scheduled two propositions related to night and child labour: one seeking to fix the minimum age for night work at 16; another seeking the minimum age for such work at 18 years old. The *Association* regarded such propositions as a serious threat that needed to be addressed. However, serious doubts arose as to whether representatives of the industry should take part in the conference of sociologists. Thoughts on this question were exchanged between the *Association* and the Ministry of Labour.[1224]

A report on the results of the conference presented to the *Association* mentioned that, thanks to the ‘energetic and skillful intervention’ of Mr. Dubois, who had consulted the

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1220 Private archive Gobbe, Association, Originaux D, Assemblée Générale du 20 février 1913

1221 Private archive Gobbe, Association, Originaux D, Rapport du Comité sur l’Exercise 1913

1222 Ulla Wikander, *Feminism, familj och medborgarskap: Debatter på internationella kongresser om nattarbetsförbud för kvinnor 1889–1919* (Göteborg and Stockholm: Makadam, 2006) [English translation available online, Ulla Wikander, “13. BERNE 1906: A CONVENTION PROHIBITING NIGHT WORK,” Personal website Ulla Wikander, accessed 27 July 2022 via http://www.ullawikander.se/wp-content/uploads/2017/04/Chapter-13.pdf]

1223 Stephan Bauer, “Past Achievements and Future Prospects of International Labour Legislation,” *The Economic Journal* 31, no. 121 (Mar. 1921): 29-30.

1224 Private archive Gobbe, Association, Originaux D, Assemblée Générale 11 juillet 1913

Association's representative Noblet on multiple occasions during the conference, 'the interests of Belgian industry' could be defended. In particular, the *Association* was able to acquire a delay in the introduction of new international legislation, forbidding night work for workers under 16 years old, of ten years after ratification. Moreover, the *Association* president proposed sending a request to the Ministry of Labour, asking them to '"win time" by delaying ratification and organising an investigation aiming to demonstrate that the window-glass industry needed apprentices of 14 to 16 years old, that that was of an "absolute necessity".'[1225] By early 1914, the *Association* even started to undertake steps to organise an international coalition (*entente*) of manufacturers, aiming to oppose social legislation at future conferences.[1226] Keeping the minimum age at 14 years old remained the ultimate goal.[1227]

This issue illustrates two important points. On the one hand, it shows that the *Association's* lobbying against new social legislation may have been quite successful even on the international level. Yet, at the same time, it suggests that the entire production system became obsolete not only in a technological, but also in a social sense, by the eve of the First World War. By 'social obsolescence', I mean that the production system could not function in new social circumstances, with, among other things, the limitations on child labour imposed by new social legislation. Indeed, if the system could not function without child labour, as manufacturers themselves claimed, it could certainly not survive for much longer without profound change, even despite the delay acquired. Of course, this 'absolute necessity' might have been an exaggeration to some degree. For instance, as already mentioned, the apprenticeship contracts were often shorter than seven years. In his monograph, Vandervelde noted that most apprenticeship contracts were in fact concluded for a term of three years. It could be assumed that the shorter contracts became popular after the introduction of tank furnaces due to a de-skilling process, yet, curiously, Vandervelde mentioned that the seven-year contracts were actually becoming more popular, making it difficult to establish a clear causality between the introduction of new technology and the term of apprenticeship.[1228] It seems therefore that starting 'early enough' (that is, at about 12 years old) was not a *conditio sine qua non* to train a glassblower. As mentioned by Vandervelde, the main incentive of bosses to push for the seven-year apprenticeship contracts was to have a cheaper workforce, as apprentices were paid less than 'senior' glassblowers.[1229] Nevertheless, the mere fact that the opposition to child labour featured so prominently on the *Association's* agenda shows how important it must have been from the industrialists' viewpoint.

Industrial schools and technical education

It is a common point in the literature that the training of glassblowers remained an informal affair, conducted on the work floor, until the introduction of mechanical glass production in

[1225] Private archive Gobbe, Association, Originaux D, Assemblée Générale 17 novembre 1913, Quote: "une enquête tendant à démonter que la verrerie à vitres a besoin des apprenties de 14 à 16 ans et que c'est pour elle une nécessité absolue"
[1226] Private archive Gobbe, Association, Originaux D, Assemblée Générale 9 février 1914
[1227] Private archive Gobbe, Association, Originaux D, Assemblée Générale 25 mai 1914
[1228] Vandervelde, *Enquête sur les associations professionnelles,* Vol. II, 115.
[1229] Ibidem, 121.

the early 20th century. Yet, on a few instances from the late 1860s on, the *Association's* proceedings recorded that the industrial schools of Charleroi and other towns in the region (*Écoles industrielles*, vocational schools) were involved in one way or another.

Such industrial schools first appeared in various cities in Belgium, such as Ghent, Antwerp, Liège, Charleroi, Huy and others, in the first half of the 19th century, with the purpose of providing evening education after work hours to the 'adult' (that is, at least 12 years old) workers. Originally, these schools were supported by local authorities (communes or provinces), but from 1853 the national government started to provide subsidies as well. The goal of industrial schools, as formulated in the ministerial report of 1879 (quoted by Grootaerts), was to 'provide a labourer with scientific instruction which he could not acquire in the workshop, to provide him with means towards the improvement of his material condition, to develop his intelligence and to initiate the knowledge of general laws that govern the transformation of matter, hence to relieve gradually the tyranny of routine.'[1230]

The curricula of industrial schools included general courses related to science and engineering such as physics, chemistry, mechanics, electricity, technical drawing and even hygiene and political economy, as well as specific courses related to industries that were prominent in the region where the industrial school was located. In all cases, the education at industrial schools remained theoretical. The industrial schools were not intended to replace vocational training and apprenticeship on the work floor.[1231]

In 1868, the Industrial School of Charleroi addressed the *Association* as it wished to organise courses for all the principal industries (of the region). The *Association* decided to grant a yearly subsidy of 600 Belgian francs to the school for two years for a daytime course. Unfortunately, no further details are provided.[1232] Nevertheless, this case is of great importance, as it provides the earliest mention of any kind of formal training for glassworkers. It is contrary to the image provided in the existing literature, where it is always emphasised that no formal training for glassblowers existed. Possibly, the course at the Industrial School was intended as supplementary to the practical training on the work floor. It is unclear whether the course was intended for ordinary workers or foremen. Be that as it may, it can be concluded that at least some attempts to organise formal vocational training were undertaken by the *Association* following the initiative of the Industrial School of Charleroi. However, it seems that this 'experiment' at the Charleroi Industrial School did not yield the expected results, because in 1872 the *Association* refused to grant them a subsidy.[1233]

Nevertheless, the question of subsidies for industrial schools reappeared within the proceedings in 1875, as the direction of the Industrial School of Charleroi asked for a subsidy

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[1230] Dominique Grootaerts, "L'enseignement technique et professionnel masculine en Belgique: aux sources d'une identité", *Revue des sciences de l'éducation* 21, no. 4 (1995): 758. Quote: "le but des écoles industrielles est de donner à l'ouvrier une instruction scientifique qu'il ne put acquérir dans l'atelier, de lui procurer par là les moyens d'améliorer sa condition matérielle, de développer son intelligence en l'initiant à la connaissance des lois généraux qui président aux transformations de la matière, le soustraire ainsi graduellement à la tyrannie de la routine"

[1231] Ibidem, 758.

[1232] Private archive Gobbe, Association, Originaux A, Séance 9 septembre 1868

[1233] Private archive Gobbe, Association, Originaux B, Séance 20 janvier 1872 of 600 Belgian francs, explicitly referring to the subsidy provided in 1868 and 1869. During a discussion on the matter, A. Andris remarked that glassworkers earned enough money to pay for the training themselves, therefore no subsidy was needed.[1234] Unfortunately, no details on the content of this training are provided, but it seems that at least some labourers followed some kind of theoretical education at industrial schools. The *Association* started to allocate a subsidy to the Industrial School of Charleroi on a yearly basis in 1878. In this year, it amounted to 600 Belgian francs.[1235] Later, other industrial schools of the Charleroi region started to receive the *Association's* subsidy as well, e.g. the schools of Charleroi (yearly subsidy of 200 Belgian francs), Gilly (100 Belgian francs), Morlanwelz (100), Jumet (100) and Gosselies (100) in 1903.[1236]

In 1884, the *Association* received a letter from the Industrial School announcing the establishment of a 'hygiene course'. The *Association* decided to demand free education for the students 'connected to the glass industry', most probably due to the fact that the *Association* already provided a subsidy to the school. No details on the content of the course were mentioned,[1237] though it was probably partly related to work safety.

Evidence of the existence of a sort of vocational-training programme related to the glass industry at the Industrial School appeared in 1887. During the discussion of the *Association*'s annual budget, it was remarked that the yearly subsidy provided by the *Association* to the Industrial School would be reduced to 100 Belgian francs only, if no 'course for the glass industry' (*cours de verrerie*) were given. At that moment, the subsidy amounted to 500 Belgian francs.[1238] While the case is not clear, there is at least a possibility that a 'course for the glass industry' was taught at the Industrial School at that time. Or at any rate, the *Association* regarded such as course as desirable.

All in all, it appears that the 'traditional' image of an autonomous and proud glassblower, guarding his old 'privileges', passing his craft along the bloodline within the family and acting as a true member of a 'labour aristocracy', was in need of adjusting. As shown above, the glassblowers' autonomy and control over labour and training was under constant pressure from the manufacturers, as is clear from the employment of 'bastard glassblowers' and the increasing control over all aspects of the glassblowers' work, especially from the 1880s on, including the imposition of workplace discipline (*Réglement d'ordre intérieur*) and the 'making of *gamins*,' which can be interpreted as the tightening of control by the manufacturers over the vocational training of apprentices on the work floor. Moreover, a sort of formal vocational training (*cours de verrerie*) seems to have existed at the Industrial School of Charleroi at least from the late 1880s on. The abolition of the system of *doubleurs* in 1904 marked a loss of workers' autonomy as well. Seen in this way, the 'traditional' image of a proud and autonomous glassblower, as appears in the aforementioned anecdotes and 'popular wisdom', can be seen as a sort of symbolic resistance to the gradual loss of this autonomy, rather than a representation of the real situation.

[1234] Private archive Gobbe, Association, Originaux C, Séance 2 novembre 1875
[1235] Private archive Gobbe, Association, Originaux C, Séance 9 janvier 1878
[1236] Private archive Gobbe, Association, Originaux D, Assemblée Générale 29 février 1904
[1237] Private archive Gobbe, Association, Brouillons II, Séance 16 février 1884
[1238] Private archive Gobbe, Association, Brouillons II, Séance 16 février 1887

Even so, it can be stated with certainty that the vocational training and apprenticeship on the factory work floor, remained the main form of training for glassblowers until the First World War, as attested by the manufacturers' firm resistance to the child labour laws. This resistance was motivated by the assumption that a long process of apprenticeship was needed in order to train a glassblower. Therefore, the training at the Industrial School must have been of a supplementary nature. On the other hand, it appears that the glassblowers' union (*Nouvelle Union Verrière*) had a great degree of control over the labour market until the early 20th century, acting as a gatekeeper.

Annealers

Annealers (a kind of oven, also known as a *lehr*) were used to flatten the glass and cool it down. It was the last step in the production process. The annealing process consisted of two operations. Firstly, the cylinder had to be warmed up, cut open in the longitudinal direction and flattened to achieve a sheet of glass. Secondly, the sheets of glass needed to be cooled down in a gradual and controlled way. Otherwise, the glass could develop internal tensions and break from a minor shock, or even spontaneously. The temperature within the annealer was 600 °C.

Until around 1824, a primitive annealer without moving parts was used. It consisted of two chambers. The glass cylinder was flattened in the first chamber. Afterwards, it was placed in another chamber manually. As soon as the second chamber was full, the whole oven was cooled down. It was a discontinuous process. Much of the glass broke along the way. Moreover, a lot of fuel was wasted as the annealer needed to be warmed up and cooled down time and again.[1239] Unlike melting furnaces, annealers were still fuelled with firewood in the first decades of the 19th century, as attested by numerous requests from the period 1810-1835.[1240] Hence, the 'traditional' annealers presented two major problems: the discontinuous work process that caused losses (glass breakage and waste of heat); and the use of firewood in the period when coal was becoming the staple fuel of industry. As for the latter problem, many requests for the establishment and expansion of glass factories from the early 19th century included a report from the 'inspector of waters and forests' (*Inspecteur Eaux & Forêts*), as was for instance the case for the *Verreries de la Coupe* (later *Verreries Bennert & Bivort*) in 1823 and *Verreries Brûlotte* (also known as *Verreries Zoude-Drion*) in 1825 (both located in Jumet). In the latter case, a specific permission to use firewood was submitted by the owner (and granted by the authorities).[1241] Although the forest inspectors never denied requests (or, possibly, rejected requests were simply not preserved), this indicates that the use of firewood was already regarded as a matter of concern, or even a problem by the public authorities back then.

From approximately 1830, multiple steps were undertaken to modernise annealers. Two problems were addressed in particular (quite often, simultaneously), namely the replacement of firewood by coal and the integration of two separate mechanisms, the

[1239] Poty and Delaet, *Charleroi pays verrier,* 47-49; Drèze, *Le livre d'or de l'exposition de Charleroi,* 450-453; Pesch, *La verrerie à vitres en Belgique*, 12.
[1240] For example, ARA-Mines, nr. 776, dossier 712; nr. 778, dossier Verrerie Delobel; ARA-Mines, nr. 777, dossier 1669
[1241] AGR-Mines, nr. 776, dossier 712 ; AGR-Mines, nr. 776, dossier Verreries Zoude-Drion

‘turning stones’ and the ‘annealing tunnel’. The former was a kind of turntable that transported the glass mechanically from one chamber to another; the latter functioned as a kind of conveyor belt, which enabled the gradual cooling of glass by transporting it away from the source of heat, while the annealer worked continually.

The first invention patent that explicitly mentioned the use of coal instead of firewood was registered in 1839 by François Houtart-Cossé, director of the *Verreries de Mariemont*.[1242] Unfortunately, it does not provide many technical details. Another patent, registered in 1842, implicitly mentioned the use of coal, while providing some rationale and technical details. The new annealer contained a cast iron plate that served to prevent the contamination of glass by coal (presumably, by isolating the fire chamber while conveying the heat), thus assuring better quality. Economy of fuel was claimed as well.[1243]

The first request to mention the use of coal for annealers dates from 1836-1837.[1244] Interestingly, in an another request dating from 1838-1839, the factory owners report the use of wood for annealers while reserving the possibility of changing to coal ‘If we deemed this process to be more advantageous’.[1245] The last mention of the use of firewood as annealer fuel dates from 1840.[1246] All later requests explicitly mention the use of coal only.[1247] It can thus be concluded that the transition to coal was effectuated by 1840 thanks to various improvements to the design of the annealer by François Houtart-Cossé, among others.

Meanwhile, other improvements to the annealers were developed as well. The first attempts to improve the annealer in Belgium in the period under consideration were undertaken shortly after 1830, again by the aforementioned François Houtart-Cossé. In a report he submitted to the Charleroi Chamber of Commerce (undated, presumably 1830s) he mentioned two of his own inventions that were meant to improve annealers at his factory. These improvements were patented by him in 1830 and 1832. Unfortunately, these two patents are not preserved in the archives, so we do not know their exact content. It seems, however, that they concerned the use of ‘moving stones’ and some way to use fuel more effectively. According to Houtart-Cossé’s report, these improvements allowed for significant cost reductions, and were adopted by all other Belgian window-glass factories within a short time.[1248]

The origins of ‘moving stones’ (*pierres tournantes*) and the ‘annealing tunnel’ (*arche à tirer*) are not entirely clear. According to the literature, the ‘turning stones’ annealer was invented in France 1825 or 1826 by a man named Aimé Hütter of the Rive-de-Gier glassworks. The annealing tunnel was introduced at the Chance factory in England in 1846.[1249] According to Bontemps, the invention of ‘turning stones’ was claimed by (unspecified) Germans. However,

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[1242] ARA-2, brevets, brevet nr.AC 1408 (1839)
[1243] ARA-2, brevets, brevet nr. AC 2148 (1842)
[1244] ARA-Mines, nr. 778, dossier 2859
[1245] ARA-Mines, nr. 778, dossier 399. Quote: “Si nous jugeons que ce procédé nous soit plus avantageux“
[1246] ARA-Mines, nr. 777, dossier 2899
[1247] For example: ARA-Mines, nr. 777, dossier 1722
[1248] ARA-Mons, Chambre de commerce, dossier 343, letter by Houtart-Cossé (1835)
[1249] Poty and Delaet, *Charleroi pays verrier,* 47-49; Drèze, *Le livre d’or de l’exposition de Charleroi,* 450-453; Pesch, *La verrerie à vitres en Belgique*, 12.

as they could not prove their priority, such as with an invention patent, he attributed this invention to Aimé Hütter in 1826. As for the annealing tunnel, Bontemps claimed to have invented it himself in 1828. However, as he could not resolve the technical problems, he had to abandon his experiments. Hütter had tried to combine turning stones with the annealing tunnel, but failed as well. According to Bontemps, it was Houtart-Cossé from Belgium who succeeded in developing a functional annealer that integrated both the 'moving stones' and the 'annealing tunnel' for the first time.[1250]

But Houtart-Cossé was by no means the only one working towards solving the problem of integrating 'moving stones' and 'annealing tunnel' into a practical annealer design. Multiple invention patents related to annealers with 'moving stones' and 'annealing tunnel' were registered in Belgium in the 1830s and 1840s. Of particular interest are three invention patents, all dating from 1839. All of them incorporate both principles (turning stones and annealing tunnel), although they are different in some small details. The transport of sheets of glass through the annealing tunnel was effectuated by small rail carts or gliding platforms. The holders of the patents are Frison, Houtart-Cossé and De Dorlodot, all known window-glass manufacturers within the Charleroi region at this time. It seems, therefore, that the annealing-tunnel principle was introduced in Belgium earlier than in England.[1251] Some interesting patents were registered in the 1840s as well. One of them summarised the turning stones, annealing tunnel and use of coal as the most important innovations. According to this patent, all annealers that were in use in Belgium at that moment (1848) were based on two basic designs: one by Laroche (this one could not be found, unfortunately) and one by Houtart-Cossé (the aforementioned patent), both patented in 1839.[1252] Another patent from 1850 provides even more insights. It mentions two systems, one by Houtart-Cossé, and another by De Dorlodot. According to the patentee, the De Dorlodot system was in fact not an original invention, but a copy of a design that was already in use in France and Germany. It had never been put to practical use, as it did not provide enough protection from contamination by coal. The Houtart-Cossé system, on the other hand, solved this issue successfully, although the exact technical details behind this success are not clear from the sources.[1253] At any rate, this case reminds us of the technical problems that had to be overcome in order to adapt annealers to coal, and the technological creativity that was required to solve this problem.

The main disadvantage of invention patents as a source is that they tell us nothing about the actual implementation of the innovations. However, various considerations strongly suggest that this new type of annealer, equipped with the 'moving stones' and 'annealing tunnel', was indeed put to practical use in Belgium in the 1830s and 1840s. First of all, the sheer number of patents for annealers issued in 1830s and 1840s (more than a dozen) suggests a systematic innovating activity within the industry, rather than isolated inventions that may have remained without practical consequences. Moreover, almost all patentees were owners and managers of glass factories, hence people with practical knowledge of the industry and its requirements. Some people held multiple patents for annealers, whereby some minor

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[1250] Bontemps, *Guide du verrier,* 286-288.
[1251] ARA-2, brevets, brevet nrs. AC 878, AC 1133, AC 1408 and AC 1428 (all 1839)
[1252] ARA-2, brevets, brevet nr. AC 4423 (1848)
[1253] ARA-2, brevets, brevet nr. AC 5135 (1850)

improvements of previous patents on annealers were protected.[1254] This suggests practical experimentation and use of the annealers. Last but not least, plans of glass factories from the requests indicate the rate of introduction of these new annealers. Plans from the 1840s show us elongated annealers, which is typical of an annealing tunnel, as was the case at the Denuite factory in 1846 or the *Bennert & Bivort* factory in the same year.[1255] However, plans from the 1830s show us 'old-fashioned' annealers without annealing tunnel.

Therefore, we can conclude that innovative annealers with annealing tunnel were first developed by the most innovative entrepreneurs (Frison, De Dorlodot, Houtart-Cossé) in the 1830s and introduced on a wide scale by other entrepreneurs in the next decade. This coincides with the switch to coal.

The next major improvement to the annealer was undertaken by Désiré Biévez, an engineer at *Verreries de Mariemont*, in 1867.[1256] Due to a sophisticated system of 'moving platforms', which transported glass through the annealing tunnel, this annealer reduced the annealing time dramatically, from 7–8 hours to only 25– 30 minutes.[1257] The exact reason for such a dramatic increase in efficiency is unclear, as the Biévez annealer follows the same basic principle as the aforementioned patents dating from 1839 and later, i.e. the mechanical transport of sheets of glass through the annealing tunnel. Interestingly, the *Bulletin du musée de l'industrie* mentioned that in the old annealers, which were replaced by the Biévez annealer, sheets of glass had to be transported manually twice. This seems to point to an 'old-fashioned' annealer without moving parts that was used in the early 19th century, as described at the beginning of this section.[1258] Possibly, despite the developments of annealers with annealing tunnels, some window-glass factories still used old-fashioned annealers without moving parts in the late 1860s when the Biévez annealer was developed. Hence, the dramatic decrease in annealing time was based on a comparison with these 'old-fashioned' annealers.

At any rate, the Biévez annealer replaced all other types. Somewhat later, it was adapted to the use of gas as fuel instead of coal by the Belgian glass manufacturer Casimir Lambert.[1259] It is not exactly known when gas fuel was introduced to the annealing process, but an invention patent from 1870 by the *Bennert & Bivort* factory mentions implicitly that the use of gas fuel was already common at that time; although some problems still occurred, the patentees claimed to have solved them.[1260]

The Biévez annealer became a de facto international standard until at least the first decade of the 20th century. Or, as a 1901 Russian encyclopaedia of Brockhaus-Yefron put it: 'The

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[1254] For example, ARA-2, brevets, brevet nrs. AC 845 (1837), AC 1133 (1838) and AC 1359 (1839), all held by Jules Frison

[1255] AGR-Mines, cartes et plans, AK3648 (Denuite); AK3641 (Bennert & Bivort)

[1256] Poty and Delaet, *Charleroi pays verrier,* 49; Engen, *Het glas in België,* 195.

[1257] Michel Chevaler, *Exposition universelle de 1867 à Paris. Rapports du jury international*. Vol. 3 (Paris: Paul Dupont, 1868), 81-82; "Four à refroidir le verre," 35-36 & 18-20; Appert and Henrivaux, *Verre et verrerie*, 253-256.

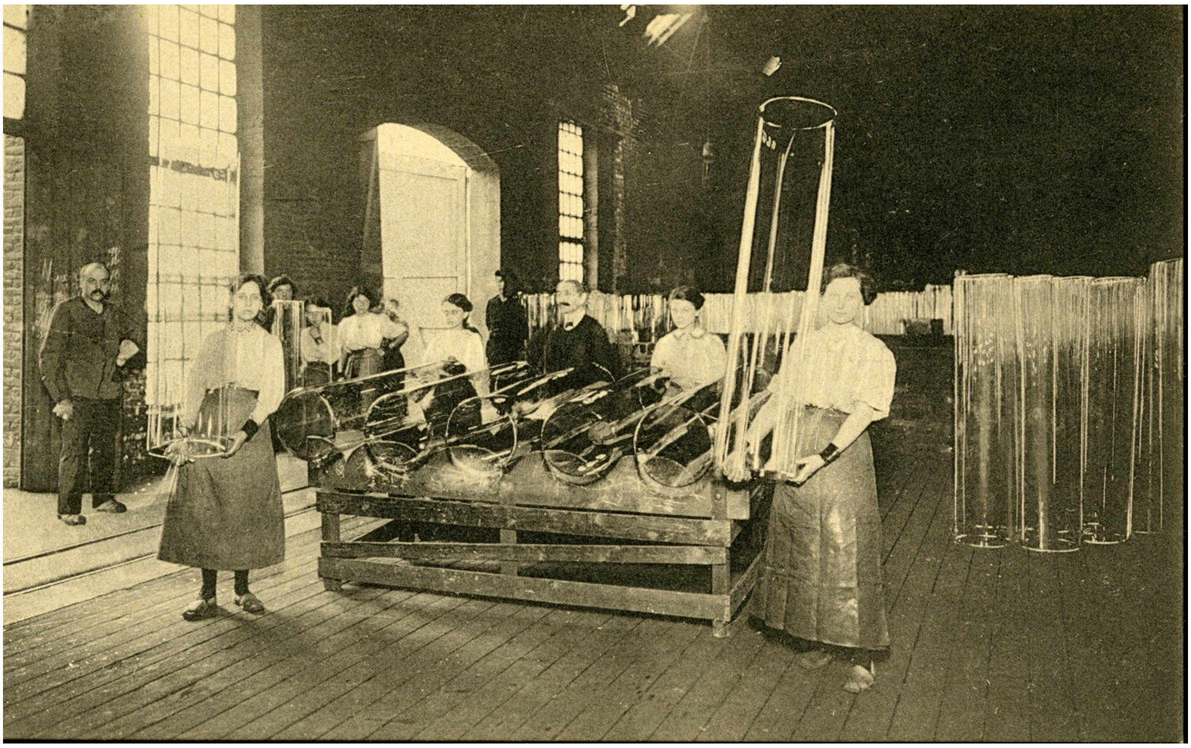
[1258] "Four à refroidir le verre," 35-36 & 18-20.

[1259] Chevaler, *Exposition universelle de 1867 à Paris,* 81-82; "Four à refroidir le verre," 35-36 & 18-20; Appert and Henrivaux, *Verre et verrerie*, 253-256.

[1260] ARA-2, brevets, brevet nr. 27649 (1870) best annealers, that are used everywhere, are designed by the Belgian Biévez of Haine St.-Pierre [*Verreries de Mariemont*].'[1261]

Here, just as in the case of melting furnaces, we witness a long process of technological development by means of a series of micro-inventions, even though the basic principles ('turning stones' and 'annealing tunnel') may have been borrowed from France or elsewhere. The technological creativity was clearly never absent.

Figure 14: Cylinders before flattening



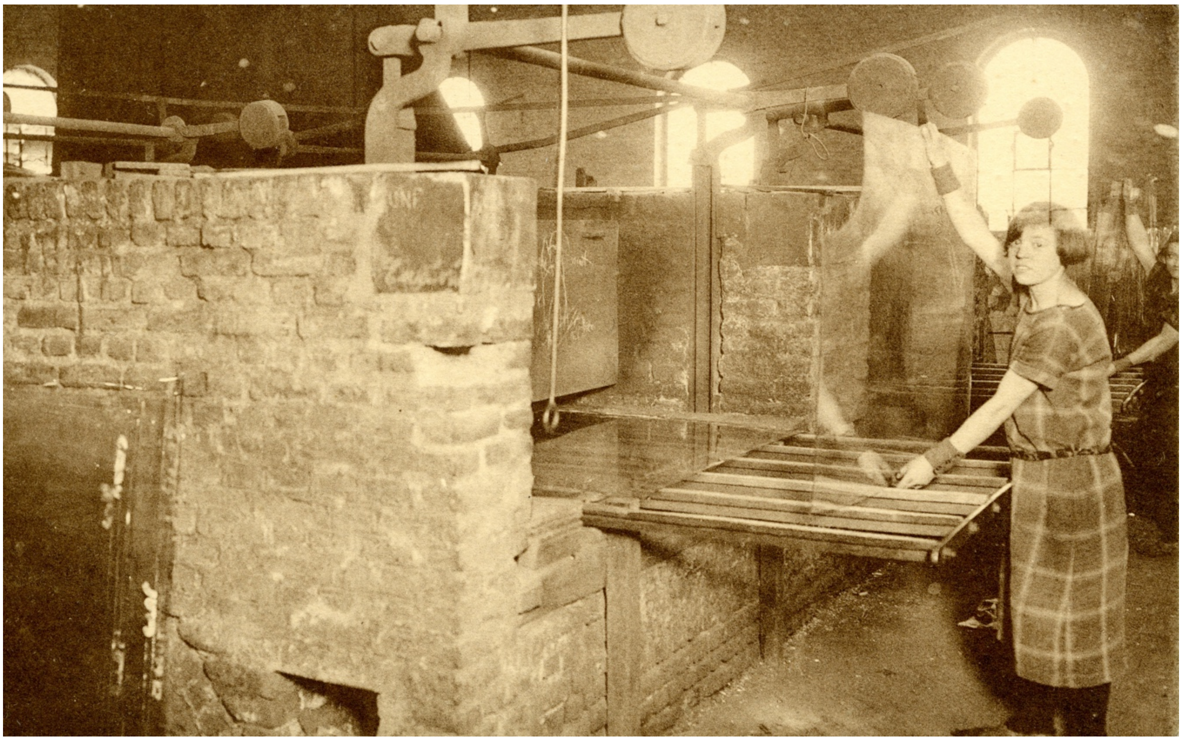
Source: © Musée du Verre, Charleroi

[1261] Sergey Petrovich Petukhov, "Steklyannoe proizvodstvo," in *Entsyklopedichieski slovar Brockhausa i Yefrona*, vol. 31a (Saint Petersburg: Brockhaus-Yefron, 1901), 582. Quote "Лучшие правильные печи, принятые всюду, устроены бельгийцем Биеве (Bievez в Haine S.-Pierre)"

Figure 15: Introduction of glass cylinders into the annealer (presumably Biévez-annealer)

Source: © Musée du Verre, Charleroi

Figure 16: Taking of flattened glass out of the annealer (presumably Biévez-annealer)



Source: © Musée du Verre, Charleroi

Mechanical production

With the exception of one rather 'experimental' factory, established by Fourcault in Dampremy for the mechanical production of window glass in the early 20th century (experimental production in 1906, normal production in 1912), the mechanical production of window glass was not introduced in Belgium until after the First World War.[1262] Therefore, as the mechanical production method did not influence the organisation of the Belgian window-glass industry during the period under consideration, it will not be discussed further here. However, as the *Association* showed keen interest in this method (albeit without many practical outcomes), it will be discussed further in the chapter on the collective management of knowledge and innovation.

Conclusion

The window-glass industry in Belgium was by no means a 'backward' traditional industry lacking innovations. Some innovations were 'borrowed' from other industries. This was the case for steam engines. The products of the innovations in the chemical industry (the artificial Leblanc soda) were 'borrowed' as well, although it took time and, presumably, technological creativity, to adapt the production to new products. At the same time, the development of the chemical industry was stimulated by the growing demand of the glass industry, as illustrated by the fact that most soda factories were integrated with glass factories. However, these were plate-glass factories rather than window-glass factories. This instance shows that other branches of the glass industry developed a stronger relationship with the chemical industry than the window-glass industry did.

The technological development within the industry itself was mostly directed at two essential pieces of equipment: annealers and melting furnaces. Both can be seen as examples of macro-inventions, at least within the industry itself. As for the annealers, it is not entirely clear whether the basic principles ('turning stones' and 'annealing tunnel') were invented in Belgium or 'borrowed' from elsewhere (France or Germany). Further development, however, took place within Belgium, with the Biévez annealer emerging as a final, 'almost perfect' result, which was clearly attested as a Belgian achievement by foreign observers.

As to the melting furnaces, the basic principle (the use of gas and melting tank) was clearly 'borrowed' from outside (Siemens). Nevertheless, very important and largely autonomous developments took place in Belgium after the initial 'borrowing' (Oppermann, Baudoux), which allowed Belgian entrepreneurs to compete with Siemens on equal terms on the global market, as exemplified by *Gobbe & Pagnoul*. Both the Biévez annealer and the tank furnace by *Gobbe & Pagnoul* attest to Belgium's contribution to the global development of glass technology.

Both cases can be seen as examples of thermal technology. Clearly, in the case of the window-glass industry, it attracted much more attention than mechanical technology, which

[1262] Cable, "The Development of Flat Glass Manufacturing Process," 27; Thomas, "La société anonyme brevets Fourcault," 223-233.

is not entirely surprising given the specific characteristics of the production process, whereby thermal energy was more important than kinetic energy. It follows therefore that the previous focus in the historiography on the (lack of) mechanisation within the industry as an indicator of 'backwardness' was misguided.

In both cases, similar challenges acted as driving forces behind the innovation. To begin with, the reduction of fuel consumption was, arguably, the main factor in both cases, albeit arguably more so for the melting furnaces. The strive to maintain and improve quality (avoid contamination from 'dirty' fuel in the case of annealers and more regular melting in the case of melting furnaces) was present as well. Moreover, there was also an intention to cut costs in other ways, such as lower labour costs due to faster work, elimination of broken glass in the case of annealers or elimination of the costly production of pots in the case of melting furnaces.

The results can be seen in the quantitative data provided by Douxchamps. In the first half of the 19th century, the production cost could be cut quite significantly. In the second half, the cost remained largely constant. However, the improved fuel efficiency of the furnaces offset the rising fuel costs. Without these innovations, the production cost would certainly have risen.

In both cases (annealers and melting furnaces), dozens of smaller improvements (micro-inventions) were made in Belgium after the initial introduction of the technology. These micro-inventions were made over longer periods of time, therefore, long waves of innovative activity are a much better representation of technological development than a few milestones, such as 1867 (Biévez annealer) or 1885 (Baudoux furnace).
The Table 21 below represents these waves:

Table 21: Long waves of innovation in the Belgian window-glass industry

Piece of equipment or production step	**Period**	**Kind of innovation**
Melting furnace	1643 – before 1800	Adaptation to coal (instead of wood)
Annealer	ca. 1830 – ca. 1870	Adaptation to coal, development of transport mechanism ('turning stones' and 'annealing tunnel'), adaptation to gas
Melting furnace	Ca. 1870 – ca. 1890	Adaptation to gas, tank instead of pots
Mechanical drawing of sheet glass	Ca. 1910 – ca. 1920	Replacement of manual blowing by mechanical power

The first and last elements of the table are largely outside the chronological scope of the article, but are included nevertheless in order to emphasise the continuous character of the innovative process. While innovation never stood still, various steps within the production process were modernised during various periods.

Using Boschma's model (clusters of innovative industries), it now becomes possible to contextualise the aforementioned developments into the development of Belgian industry in general. If we are to relate to the clusters as defined by Boschma, it can be concluded that the window-glass industry was strongly embedded in the first Industrial Revolution phase (1770-1800). While the use of steam engines remained limited, the window-glass industry was one of the first to switch to coal, making it strongly dependent on one of the key sectors of the Industrial Revolution (Boschma's steam-coal-iron cluster). Moreover, the Belgian window-glass industry can be related to the textile-chemical cluster to some degree. While Boschma referred to textile bleaching only, the emergence of the artificial soda industry (Leblanc process) is exemplary for the early chemical industry as well. Hence, the switch to the artificial Leblanc soda bears testimony to the linkage between the window-glass and the chemical industry in the early 19th century.

The railway phase (1830-1850) and its only steam-transport-iron-cluster is related to the development of logistics in the window-glass industry, as it heavily relied on railway and maritime transport for its worldwide exports. Less directly, the development of steam technology within this cluster also had important consequences for the window-glass industry, albeit somewhat later when it started to use steam boilers in combination with gas producers for tank furnaces in the 1880s.

As for the second Industrial Revolution phase (1870-1900), the linkages are less prominent. Yet, the development of regenerative and tank furnaces can be related, albeit somewhat indirectly, to the steel cluster, as the development of these glass furnaces was inspired by the metalmaking furnaces – the Siemens brothers first developed the regenerative principle for the steelmaking furnaces. The application of electricity is directly related to the electrical cluster, of course.

The overall picture indicates that the window-glass industry was certainly (inter)connected with the sectors and technological developments of the first as well as second Industrial Revolution. As suggested by the model, the innovations within the window-glass industry did not occur in isolation. Directing our attention to the mechanisms behind the connections with other industries, we can conclude that producer-user relationships mechanisms were certainly present for the cases of new energy sources (coal) and components (artificial soda). The development of the regenerative and tank furnace is somewhat more difficult to classify in this respect, yet technical interdependency mechanism seems most fitting in these cases, as the initial development of heat exchangers and other furnace technology in one industry (metallurgy) ultimately resulted in a technological revolution in glassmaking.

And yet, the interrelationship between the window-glass industry and the general development of the industry as a whole is less strong than for many other industries, such as textiles or mechanical engineering, which relied heavily on the use of steam power and mechanical machinery, thus creating stronger connections with the steam-coal-iron cluster of the first Industrial Revolution or steel and mechanical clusters of the second Industrial Revolution. This certainly points to some specificities of the window-glass industry that distinguished it from many other industries.

Most of the creative energy was directed towards the development of thermal technology (annealers and melting furnaces), which features rather indirectly within Boschma's model. In my opinion, a whole new perspective could be achieved by distinguishing the pyrotechnological cluster in its own right. This cluster would encompass the development of furnaces in various contexts, such as various branches of the metallurgy, ceramics, and glass industry. This would provide a valuable addition to Boschma's model and would include multiple aspects, such as the treatment of heat (heat exchangers), the application of various types of fuel (coal, oil, natural and artificial gas) and the related material science and technology (refractory materials). In my view, the study of this pyrotechnological cluster in its own right would contribute greatly to the interlinkages in the development of many seemingly unrelated industries and technologies, such as the aforementioned ceramics and glass, and various branches of metallurgy as well as, possibly, even domestic heating and cooking.

Turning our attention to the relationship between innovation and craftsmanship, it is clear that embodied skills and craftsmanship remained of paramount importance until the proliferation of mechanical production after the First World War. The long-established community of highly skilled workers was one of the most important advantages of the Belgian window-glass industry. Their importance is clearly illustrated by the high wages, as well as by anecdotal evidence. In relation to this, the property of skill (and having the 'right blood' as it was known in the case of glassblowers in Belgium) was manifest, as exemplified by the strict maintenance of a social distinction between glassblowers ('hot workers') and 'cold workers'.

However, as appears from the *Association*'s proceedings as well as other sources, the property of skill and the autonomy of glassblowers was threatened by factory owners, who strived to expand their control over the glassblowers. Moreover, the work of the glassblowers changed as well. Some micro-inventions, such as the introduction of the *manique*, allowed for the production of larger sheets of glass, while the invention of the tank furnace reduced work autonomy and led to a greater division of labour, although the question of de-skilling remains debatable.

All in all, the Belgian 19th-century window-glass sector was a truly hybrid industry in the sense described by Berg and Hudson, whereby traditional craft skills went hand in hand with the never-ending stream of technological creativity and innovation, often in the form of micro-inventions. They might have been 'small' and even 'trivial' at times, but the aggregate effect surely added to the overall development of the industry.

If we return finally to the four main characteristics of the Industrial Revolution, we can conclude the following: regarding the 'substitution of skills' (1), we note only modest (if any) de-skilling due to the tank furnace; the use of steam power (2) remained limited, but it was used wherever it could be applied easily; the new materials (3), such as artificial soda, were 'borrowed' from the chemical industry, while their application certainly required technological creativity; finally, the coal-burning technology (4) experienced very strong (even revolutionary) development within the industry itself.

Of course, the entire production system started to show signs of obsolescence by the late 19th century, and even more so by the early 20th. This can, at least partly, be explained by a sub-optimal knowledge-management. For instance, despite its efforts (see chapter on knowledge-management strategies), the *Association* did not succeed in introducing any important innovations. Moreover, the *Association* only aimed at acquiring knowledge from foreign sources, never attempting to establish its own research & development department, for example.

Alongside the fall-back in terms of technological innovation (see Chapter 3.2 on the analysis of invention patents), the production system became obsolete from the social point of view. According to the manufacturers, child labour was necessary to maintain the high level of craftsmanship. Unfortunately, we do not possess any other sources on this issue except those directly representing the manufacturer's viewpoint (the *Association*'s proceedings). Because of this, it is impossible to judge with certainty whether the production system really could not function without child labour, as the manufacturers insisted. Possibly, a certain degree of exaggeration was present. Yet it seems at least plausible that child labour had a crucial (albeit not necessarily inevitable) place in the entire production system, leading to increasing tensions in the face of the emerging legislation. In this respect, it can be stated that the advantage that assured the industry's success during the largest part of the 19th century (the combination of technological innovation and manual skill) turned into a disadvantage by the late 19th century due to both technological and social developments.

Chapter 3.4: Properties and qualities of glass

This chapter will examine the degree to which the properties and qualities of glass changed due to the technological developments discussed above. As the 19th-century window glass industry was dependent on technological developments as well as 'traditional' craftsmanship, the question will relate to whether the properties and qualities of glass were defined by the technological innovations of 'traditional' craftsmanship in the first place.

Moreover, hypothetically, the distinction of qualities, and even more importantly of 'special glass' can have direct consequences for the specialisation of individual firms as well as the organisation of the industry as a whole. This can be directly linked to concepts such as 'flexible specialisation', which are considered to have been especially relevant for the industrial-district context, as already discussed in the theoretical chapters. Therefore, the specialisation of individual firms as well as the organization of the industry as whole will be discussed in this chapter as well.

Ordinary (clear) window glass

Qualities

By the early 19th century, a basic distinction was made between the *verre commun*, glass of lesser quality (sometimes also designated as *verre vert*, green(ish) glass) and *verre blanc* of better quality. Other designations, often referring to the geographical origin such as *verre d'Alsace* and *verre de Bohême* were used as well. However, due to the intensification of international knowledge exchange as well as the technological development starting from the late 18th-early 19th century, the geographical designations gradually lost their significance; after all, *verre de Bohême* (or any other geographically defined sort of glass) could be made elsewhere as well.[1263] For example, a practical treatise on architecture published in 1829 considered *verre blanc* and *verre de Bohême* as synonyms. This example shows that by then, the indication *de Bohême* referred to quality and not first and foremost to the geographical origin.[1264]

Bontemps made a threefold distinction (from better to lesser quality) between *verre de Bohême* or *verre blanc*, *verre d'Alsace* or *verre demi-blanc* and *verre commun*. The luxury *verre de Bohême* contained potash, while the ordinary *commun* (lesser quality) glass was soda based. Unfortunately, no details on the composition of *verre d'Alsace* or *verre demi-blanc* are provided. While potash provided for the better quality, it was more difficult to work with, as the potash melt was less liquid and hence less 'blowable'. Therefore, *verre blanc* or *verre de Bohêm*e was more expensive than *verre commun* (ordinary glass). According to the same author, the distinction between the three 'old' types of glass disappeared after 1840 due to changes in the basic composition such as the introduction of artificial soda. The new composition allowed for the production of glass of the same high quality as the old *verre de Bohême*. Hence, this is a clear example of the influence of technological innovation on product quality. After 1840, there was still a distinction being made between *verre blanc* and *verre demi-blanc*, whereby *verre blanc* contained less *grosil* (re-used glass shards known as cullet).[1265]

The same system was applied in Belgium as attested by Belgian sources. The distinction between *verre commun* and *verre blanc* remained in use in Belgium until the middle of the 19th century. Between 1821 and 1829, the catalogue of the *Verreries de Saint-Roch* (the same as the *Verreries du Château de Lodelinsart*), near Charleroi, mentioned *verre demi-blanc* and *verre commun façon d'Alsace*.[1266] In 1837, the *Revue belge* mentioned the production of *verre à vitre blanc* and *verre à vitre vert ou commun* in Belgium.[1267]

From the mid-19th century, a distinction in four qualities (or four choices) emerged. An invoice for the delivery of glass by the *Société des Manufactures* to a client in Belgium, dating from 1845, mentions both *verre 2^e^ choix* as well as *verre vert*.[1268] This seems to point to a transition period, with the 'old' designation (*verre vert*) being used simultaneously with a new (*verre 2^e^ choix*, second choice). During one of its first meetings, in 1848 already, the *Association* distinguished four choices when it fixed the prices.[1269]

From approximately 1850, the new system largely replaced the old one, while taking on an international character at the same time, as confirmed by price lists for window glass from various countries that are preserved in the archives of the Musée du Verre. The oldest example is an 1850 price list for French and American glass of the trading house *Schanck,*

[1263] Langouche, "The look of window glass," 83.

[1264] C. J. Toussaint, *Memento des architectes et ingénieurs, des entrepreneurs, toiseurs, vérificateurs et des personnes qui font bâtir* (Paris Toussaint [chez l'auteur], 1829), Tome premier, 85.

[1265] Bontemps, *Guide du verrier*, 71, 265-266, 309-310.

[1266] Drèze, *Le livre d'Or de l'exposition de Charleroi*, 439.

[1267] *Revue belge* 6 (1837), 111-112.

[1268] Archives of the Ghent University Library (Boekentoren), collection Efemera – Vliegende bladen, Verre 5, BIB.VLBL.HFIII.PGV.001.05

[1269] Private archive Gobbe, Association, Originaux A, 28 novembre 1848, Assemblée de verriers des environs de Charleroi

Downing & C° (New York). The 1865 English list of St. Helen's crown, sheet, and plate glass C° is somewhat different, as it mentions 'Picture qualities A and B, glazing qualities best, 2nd, 3rd, 4th'. Possibly, 'picture qualities A and B' refer to the glass for picture frames. Belgian examples from 1860 and 1865 mention four qualities of ordinary window glass, as well as 'green glass' for glasshouses.[1270]

Nevertheless, the designation of glass as *extra-blanc* still appeared sporadically, as was the case in a price list of the French *Verreries de Velars-Sur-Ouche* in 1866 (price list),[1271] and by the letter head of the Belgian *Verreries des Piges* from Dampremy, near Charleroi, in 1919.[1272] Possibly, this was the way manufacturers tried to emphasise the (presumably) outstanding quality of their products.

The exact relationship between the 'old' (*verre commun*, *verre demi-blanc* and *verre blanc*) and 'new' (four qualities) system is not exactly clear. However, it seems plausible that as the *verre commun* disappeared from the sources in the second half of the 19th century (except as 'green glass' for glasshouses), all four qualities under the new system were of *blanc* quality. Indeed, as the technological developments of various kinds (chemical production of primary components, tanks furnaces, etc.) made the entire glass-making process more controlled, the tint, thickness and quality became the main system for the classification of glass. The tint varied between *demi-blanc* and *extra blanc* depending on the proportion of 'fresh' to 'second-hand' (cullet) composition, while the assignment of 'qualities' depended on the number of defects or flaws of the glass. [1273] Explicit mentions of aspects that defined qualities (including the exact meaning of 'shortcomings' and 'defects') are very rare in sources. The available definitions will be discussed further.

This international classification system remained valid until the early 20th century, as is clear from contemporary publications. Alongside the basic distinction in four qualities (the first being the best and the fourth the worst), subdivisions were mentioned as well. The finest quality, even superior to the 'ordinary' first choice, was described as the 'first choice extra' (*1er choix extra*) or 'selected quality' (*qualité selected*, whereby a curious mix of French and English terminology was used). On the other hand, the worst sheets of glass, with the most defects, actually comprised the fifth quality, but were designated as 'fourth quality export' (*quatrième exportation*). This quality was almost exclusively exported to China. Interestingly, inferior quality glass was exported to the United Kingdom as well, under the designation of *coarse*.[1274] It is not entirely clear whether *coarse* was the same as *quatrième exportation*, but several mentions in the *Association*'s proceedings show that it was cheaper than the fourth choice. For instance, in 1868, it was remarked that the price difference between fourth quality and coarse amounted to 1 shilling and 6 pence. Unfortunately, the exact unit of measure was unclear. Neither were price differences between other qualities (between the

1270 Archives Musée du Verre, Charleroi, Divers, DIV 45
1271 Archives Musée du Verre, Charleroi, Divers, DIV 45
1272 Archives Musée du Verre, Charleroi, Divers, DIV 81
1273 Langouche, "The look of window glass," 83-84
1274 Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 150-151; Lalière, "Les industries du verre," III. 6, p. 15-16

first and second, second and third, third and fourth) mentioned. Yet, at any rate, the fact that *coarse* was cheaper is indicative of a lower quality.[1275]

The criteria for the distinction between qualities are given as follows: 'According to the purity of the melt and, first and foremost, corresponding to the defects which may have occurred during each of the operations'.[1276] Given the vagueness of these criteria, it should not be surprising that interpretations could differ. There are, indeed, clear indications that this was sometimes the case. In particular, the criteria could differ between markets. For example, speaking in 1878, Léon Baudoux, a prominent Belgian glass manufacturer, noted that the English fourth quality was equivalent to the Belgian third quality.[1277] A 1913 monograph mentioned explicitly that the classification varied according to the specific conditions of each country and, in particular, 'the level of civilisation'. For instance, the fourth quality destined for China was always inferior to the fourth quality for Canada.[1278]

The 'ordinary' fourth quality was still regularly exported to the countries regarded as civilised by contemporaries at least until the late 19th century. For example, in 1887, the majority of Belgian exports to Canada comprised fourth-quality glass.[1279] In the same year, the United States consumed a large portion of fourth-quality glass as well.[1280] Moreover, the *coarse* glass, being of even lesser quality than the fourth, featured prominently within exports to the United Kingdom for decades, from the late 1860s to the late 1890s.[1281] However, this particular case can at least partly be explained by the re-export of *coarse* glass to the British colonies.

On one particular occasion in 1868, *coarse* was explicitly described as 'the fifth quality'. It is almost exclusively mentioned in the context of export to England. One time, exports of *coarse* to Ireland was mentioned as well. Interestingly, the Irish market was (implicitly) regarded as distinct from the English. Still on the same occasion in 1868, the difference between the 'Belgian and English qualities' was mentioned, implying that the criteria for the distinction were more or less subjective.[1282] Hence, while the four-qualities system was used internationally from approximately 1850s on, this does not necessarily imply that the criteria were the same everywhere.

Unfortunately, the sources almost never mention any exact criteria of good quality explicitly. Therefore, it is difficult to draw a causality between technological improvements, such as the developments of the new types of annealers, and the quality of the glass. One interesting source that sheds some light on this question is a report on Belgium's participation in the Great Exhibition of 1851 in London. It provides a description of the window-glass specimens

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1275 Private archive Gobbe, Association, Originaux A, Séance 7 décembre 1868

1276 Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 150, Quote: "Selon la pureté de la pâté, et, surtout, d'après les défectuosités qui ont pu se produire au cours de chacune des opérations"

1277 Private archive Gobbe, Association, Brouillons I, Séance 2 novembre 1878

1278 Lalière, "Les industries du verre," 16.

1279 Private archive Gobbe, Association, Brouillons II, Séance 11 juillet 1887

1280 Private archive Gobbe, Association, Brouillons II, Séance 21 novembre 1887

1281 Private archive Gobbe, Association, Originaux A, Séance 7 décembre 1868; Private archive Gobbe, Association, Originaux C, Assemblée Générale 30 novembre 1896

1282 Private archive Gobbe, Association, Originaux A, Séance 7 décembre 1868 by various Belgian factories that were presented at the Exposition. The glass by *Jules Frison et Cie* (Dampremy) and *Bennert & Bivort* (Jumet) was regarded as of fine quality due to the perfect and faultless annealing. The glass from these factories was described as follows: 'The [sheets of] glass are quite properly flattened [that is, the cylinder had been annealed fairly flat], without 'points' [there are no air bubbles, protrusions etc.] and had preserved their entire lustre; their brightness is beautiful, dazzling; the only valid criticism that could be made about these magnificent products is that they [sheets of glass] are not perfectly straight, a defect that arises from insufficiently long annealing within the annealer'.[1283]

The glass of another Belgian participant, *Cappellemans aîné & Deby* (Saint-Vaast) was of lesser quality. However, 'its essential quality was of being completely straight; on this instance they [sheets of glass] appeared superior to the glass of *Frison et Cie* and *Bennert & Bivort*.'[1284] The French glass was described as beautiful (*belle*), but of somewhat lesser quality when compared to Belgian because of a large number of 'points' (*piquers*, air bubbles, protrusions, etc.) due to bad annealing. Moreover, French glass was 10 to 15% more expensive than Belgian.[1285]

This example illustrates the importance of the annealing process (and hence of the annealers) for maintaining glass quality, as well as various criteria that defined this quality. Some of these criteria are more or less 'objective', if difficult to quantify ('points', straightness of sheets of glass), while others, such as 'brightness' are even more subjective.

Another indication of the criteria used to classify glass is to be found in Bontemps' treatise. In it, sheets of glass were classified in categories upon their arrival at the factories' storehouses. Bontemps mentions several possible deficiencies. Bubbles could occur during the gathering of glass (presumably due to the glassblowers' lack of skill), or while working with a dirty cane. If the 'cylindricity' of a cylinder was insufficient, the resulting sheet of glass would not be straight enough. Moreover, the 'bad blowing' of a cylinder could result in the unequal thickness of the sheet of glass. Apart from the blowing stage, (unspecified) deficiencies could appear during annealing as well.

Upon visual inspection, taking these possible deficiencies into account, each sheet was assigned to a certain 'choice' (undoubtedly, this referred to one of the four choices or qualities mentioned above) by the storekeeper (*magasiner*). Hence, the storekeeper acted as a quality inspector. This way of working referred to the French practice, but it seems highly likely that the same (or at least similar) practice had been followed in Belgium as well.

Hence, the quality inspection and classification by quality was done 'by eye' quite literally, based on the storekeeper's judgement. This, again, reaffirms the conclusion that the distinction of qualities was based on a subjective judgement rather than on any clear

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[1283] *L'indépendance belge*, 20 octobre 1851, Quote : "les verres sont très-convenablement-aplatis, sans piqures, et ont conservé tout leur lustre; leur blancheur est belle, éclatante; une seule critique fondée peut être faite concernant ces magnifiques produits, c'est qu'ils ne sont pas complètement droits, défaut qui provient de ce qu'on ne les a pas laissé refroidir dans l'ache, pendant un temps suffisamment long"
[1284] Ibidem, Quote: "mais leur qualité essentielle est d'être parfaitement droits; sous ce rapport, elles semblent supérieurs aux verres de Frison et Cie et Bennert & Bivort"
[1285] Ibidem

objective criteria. However, Bontemps mentioned a kind of device used by 'Mullensiefen of Cregueldanz' (sic, without doubt the firm of Müllensiefen brothers in Crengeldanz, see chapter on knowledge management) to check for annealing defects. The device as described by Bontemps (there was no drawing provided) consisted of a large, flat wooden panel painted in black, that was mounted on two pivots above its centre of gravity similar to a dressing-table mirror. At the bottom of the panel, there was a small plank (shelf) on which to put the sheet to be examined, and a rope was attached to this small plank in order to move the entire panel. By placing the sheet upon the panel, the examiner could judge whether the sheet was entirely flat. Next, by pulling the rope and hence observing the sheet under different inclinations against the light, the examiner could observe all possible shortcomings, such as 'points' and 'bumps' (*piqûres, bosses*).

Bontemps did not mention whether this device was used elsewhere, nor was any mention of it to be found in Belgian sources. At any rate, the device was nothing more than a kind of mobile support that merely made the examiner's task easier, while the visual observation and examiner's own judgement without clear – or at least easily quantifiable – criteria (at least not mentioned in any source) remained the basis for the classification of glass by quality.[1286] Apart from visual examination, no 'testing' of any kind, such as mechanical strength of specimens, was ever mentioned.

In addition to the annealing technique, the glassblower's skill was of crucial importance for the glass quality; without it, irregularities and flaws such as bubbles could appear. Alongside glassblowers, Bontemps mentions that *étendeurs* who flattened cylinders into flat sheets and operated annealers were also essential for the quality. Quite obviously, the process of flattening was a delicate one, as the *étendeur* had to maintain an appropriate temperature in the annealer, described by Bontemps as 'not too high and not too low' without any exact values.[1287] It should be kept in mind that measuring high temperatures in 'industrial' settings remained problematic until the early 20th century, when reliable practical thermocouples and radiation pyrometers became available. Before that time, experienced furnace operators could judge the temperature by the colour of radiation, albeit not in a quantitative way.[1288]

Hence, both 'technology' (annealers in this case) and 'skill' (glassblowing) were defining factors for the quality of glass. Yet the operation undertaken by annealers was 'skill-dependent' to a large degree. It can therefore be concluded that, until the early 20th century, the quality of glass remained highly dependent on the skill and tacit knowledge of various workers. Moreover, the assignment of glass produced to one of the four choices or qualities remained dependent on the judgement of an examiner (or the storekeeper), which must also have been based on tacit knowledge rather than any quantifiable criteria.

On very few occasions, causality between technology and glass quality is mentioned in sources more or less explicitly. For example, according to an account published in 1912, the first quality 'of forty years ago' (that is, about 1870, before the introduction of tank furnaces) would 'now' be regarded as the fourth quality. This improvement was attributed to the much

[1286] Bontemps, *Guide du verrier*, 300-301.
[1287] Bontemps, *Guide du verrier*, 298-299.
[1288] M. Cable, "The advance of glass technology in the nineteenth century," 116-117.

better (regular and controlled) melting process in the tank furnace as compared to the older pot furnaces.[1289]

Thickness

The thickness of window glass is not often mentioned in sources explicitly. Writing in 1868, Bontemps mentioned that the thickness increased over time. According to him, in the time of the *Encyclopédie* (late 18th century), one square metre of glass weighed 3.5 kg, while by his day the weigh had increased to 4.5 kg.[1290] Assuming the density of window glass to be 2.500 kg per m^3, this means a thickness of 1.4 mm for the former and 1.8 mm for the latter.[1291] These are, obviously, approximative values, as the density for modern glass was used for the calculations.

By the early 20th century (possibly earlier), the thickness of glass became standardised in Belgium, as represented by the Table 22 from a contemporary publication.[1292] Here, the weight is given in ounces (28.35 g) by English square feet (0.0292 m^2)

Table 22: Standard thickness and weight (by English square feet) of window glass in the early 20th century

	Thickness (mm)	Weight (ounce)
Verre mince (thin glass)	1 to 1.5	10 to 14
Verre simple épaisseur (glass of ordinary thickness)	1.5 to 2	14 to 18
Verre demi-double (half-double thick glass)	2.25 to 3	21 to 26
Verre double (double glass)	3 to 3.5	26 to 30
Verre triple (triple glass)	3.5 to 4	32 to 36

Source: Lalière, “Les industries du verre,” III. 6, p. 15-16.

It is interesting to note that thickness and size have a direct connection with the ‘heatwork’, that is, the availability of the same temperature over a relatively long period. This ensured that the glassblower could gather a larger quantity of glass melt and reheat it multiple times during the glassblowing process. As a result, he could produce a larger and thicker glass cylinder.[1293]

The glass for photography (i.e. glass for photographic plates) was considered a type of window glass (presumably due to the fact that it had been produced by the same technique), with the special classification according to thickness. The thickness of photography glass was defined as presented in the Table 23[1294]:

[1289] G. Drèze, *Le livre d’Or de l’exposition de Charleroi*, 450.
[1290] Bontemps, *Guide du verrier*, 245-246.
[1291] Source for the window glass density: Saint-Gobain, “Mechanical properties of glass,” accessed 11 April 2023 via https://uk.saint-gobain-building-glass.com/en-gb/architects/physical-properties
[1292] Lalière, “Les industries du verre,” III. 6, p. 15-16.
[1293] Communication by Joost Caen (01.07.2022, by e-mail)
[1294] Lalière, “Les industries du verre,” III. 6, p. 15-16.

Table 23: Standard thickness and weight (by English square feet) of glass for photographic plates in the early 20th century

	Thickness (mm)	Weight (ounce)
Verre gros	1.8	14
Verre ordinaire	1.7	13
Verre fin	1.6	12
Verre mince	1.0	9
Verre extra-mince	0.6	*No value given*

Source: Lalière, "Les industries du verre," III. 6, p. 15-16.

Dimensions

The mean size of window glass increased from the 18th through to the 19th and early 20th century. This general tendency can first be illustrated by a couple of international examples. For instance, according to Bontemps, at the time of the *Encyclopédie* (late 18th century), the size of window-glass panes amounted to 20 x 12 inch (51 x 30.5 cm, all conversions to centimetres are approximative) or 18 x 14 inch (46 x 35.5 cm). 'Later' (Bontemps did not provide the exact date here) the size increased to 25 x 20 inch (63.5 x 51 cm) and 29 x 18 inch (73.6 x 46 cm). By 1868 (publication date of Bontemps' book), the sizes had increased to 111 x 69 cm and 99 x 81 cm.[1295]

Another example can be provided as well. According to a Dutch architectural treatise '*De Burgerlijke Bouwkunde of verhandeling over eenige gebouwen, derzelver gronden, doorsneden en gedeeltens, volgens de nieuwste wijze*' by Johannes Van Straaten (1814, quoted by Stokroos), the maximal size of Bohemian glass at that time amounted to 36.5 x 28 Rhinish inch, i.e. 94 x 73 cm. In 1834, the city of Amsterdam ordered glass panes equivalent to 86 x 73 cm. In 1843, the maximum dimensions of German glass amounted to 40 x 28 Rhinish inch or 104 x 73 cm. Yet it should be kept in mind that it is difficult to draw all too definitive conclusions from these examples, as it is not always clear whether they related to the truly largest sizes that could be produced at the time, or to the largest sizes to be found in regular commerce. Moreover, the distinction between blown window glass and cast plate (mirror) glass is not always clear, as, for instance, in 1852, glass plates of 310 x 218 were available as well. These obviously related to the cast plate glass.[1296]

As for Belgium in particular, the maximum sizes throughout the 19th century are provided by Lefèbvre, together with the weight and number of cylinders that could be produced on a daily basis (presumably, by one glassblower). All later literature reproduces these numbers. Unfortunately, Lefèbvre did not provide any specific source, neither is it clear whether these were the largest sizes that could have been produced physically, or the 'largest economical' sizes that could be produced in large quantities for the large market. Therefore, the number should probably be regarded as indicative, not absolute.[1297]

1295 Bontemps, *Guide du verrier*, 245-246.
1296 Meindert Stokroos, *Bouwglas in Nederland. Het gebruik van glas in de bouwnijverheid tot 1940* (Amsterdam: Gemeentelijk Bureau Monumentenzorg, 1994), 16.
1297 Lefèbvre, *La verrerie à vitres*, 54.

As for the units of measures, the Belgian window-glass industry 'officially' employed the French inch of 2.707 cm (this value was used for the conversion). However, the 'interpretation' could vary to some degree, so that in some factories an inch amounted to almost 3 cm.[1298] As for the weight, no clear indication of the exact value was mentioned. Approximately, the value of 0.490 kg was used for the conversion.

In the Table 24 (after Lefèbvre, 1938, p. 54), the column with dimensions in 'united inches' was added to ease comparison with other sources.

Table 24: Evolution of the size of window-glass panes, 1825-1870

Year	Dimensions (French inch)	United inch	Weight (ponds)	Number of cylinders a day
1825	20 x 12 (54.1 x 32.5 cm) or 18 x 24 (48.7 x 65 cm)	32 or 42	1.5 (0.735 kg)	160 to 180
1830	24 x 20 (65 x 54.1 cm) or 28 x 18 (75.8 x 48.7)	44 or 46	3 (1.47 kg)	80 to 90
1845	40 x 24 (108.3 x 65 cm)	64	8 (3.92 kg)	60
1870	48 x 32 (129.9 x 86.6 cm)	80	8 to 14 (3.92 to 6.86 kg)	100 to 120

Source: Lefèbvre, *La verrerie à vitres*, 54.

Lefèbvre attributed the increase in size to various devices, such as the *lanceman*, which made the glassblower's work easier by supporting his cane, as previously described. Nevertheless, there appeared to have been a limit to what a human could produce. According to Lefèbvre, the sheets of 48 x 32 inch (or 84 'united inch'[sic]), corresponding to about 1.5 square metres, remained the largest size that could be achieved by manual blowing in spite of all improvements. Only exceptionally strong glassblowers could reach the size of approximatively 80 'united inch'.[1299] The exact reason for limiting the maximum size (due to the weight or capacity of human lungs) as provided by Lefèbvre is unclear. And yet, Bontemps provided a price table for the (French) window glass with maximum sizes of 102 x 150 and 42 x 210 cm, which would approximately equal 100 'united inches'.[1300] Moreover, Bontemps mentioned that Belgium was specialised in the production of (relatively) smaller sheets of glass, the standard size of Belgian window glass being 30 x 24 inch (36.2 x 61 cm), while the production of large formats such as 40 x 30 inch (102 x 36.2 cm) remained limited in Belgium.[1301] However, it is known that some Belgian factories produced very large formats as well. For example, the *Bennert & Bivort* factory, which specialised in large formats, produced window-glass sheets as large as 262 x 109 cm in 1876.[1302] A comparison with other sources makes the semi-linear progression appear less straightforward than presented by

[1298] Poty and Delaet, *Charleroi pays verrier*, 46.
[1299] Lefèbvre, *La verrerie à vitres*, 54.
[1300] Bontemps, *Guide du verrier*, 313.
[1301] Bontemps, *Guide du verrier*, 315.
[1302] *Exposition internationale de Philadelphie en 1876. Belgique. Catalogue des produits industriels et des œuvres d'art* (Brussels: Parent et C[ie], 1876), 20.

Lefèbvre. For instance, a tariff table as recorded in the *Association*'s proceedings in 1848, can be given as an example (Table 25).

Table 25: Tariff table with sizes and qualities of window glass, 1848

Dimensions ('united inches')	1st choice	2d choice	3d choice	4th choice
14 to 25	19	16	12	9.75
26 to 40	21	17.50	13	10.75
41 to 50	25.50	21	14.50	12.50
51 to 60	32	26	15.50	14
61 to 74	37	29	16.50	14

Source: Private archive Gobbe, Association, Originaux A, Séance 28 novembre 1848

The dimensions were provided in *pouces réunies* ('united inches', i.e. the sum of the length and width of a sheet of glass); the prices are in Belgian francs per 'square foot' (most probably, per 100 square feet was meant).[1303]

As appears from the table, sizes up to 74 'united inches' were already practical in 1848, which contradicts Lefèbvre's claim. Moreover, a tariff table dating from 1853 (Table 26) already mentions a category of sheets between 80 and 85 'united inches', while, according to Lefèbvre this maximum size could only be reached after 1870:

Table 26: Tariff table with sizes and qualities of window glass, 1853

Dimensions	N°1	N°2	N°3	N°4
Up to 25 'united inches'	23	18.75	13.75	11
26 to 40	26	21	15.75	12.25
41 to 50	31.25	25.50	18.50	15
51 to 60	40.75	33	19.75	16
61 to 74	46.25	37.50	21	16.50
75 to 79	50	41	23	18
80 to 85	55	45	25.25	20

Source: Private archive Gobbe, Association, Originaux A, Séance 18 juillet 1853

The prices as indicated in the table were valid for Europe except England, in Belgian francs per 100 square [French] feet (*mesure française*).[1304] The prices indicate that producing larger sheets of glass required more skill, as the price per 100 square feet increased sharply with the size of a sheet. In other words, 100 square feet of small sheets under 25 'united inches' was almost three times cheaper than the largest sheets of 85 'united inches'. The price difference between the first and fourth qualities is telling as well.

[1303] Private archive Gobbe, Association, Originaux A, Séance 28 novembre 1848
[1304] Private archive Gobbe, Association, Originaux A, Séance 18 juillet 1853

It can therefore be concluded that the maximum size that could be produced manually, i.e. approx. 80 'united inches' or approx. 1.5 square metres, could already be achieved by the mid-19th century. It is plausible that later improvements made the process easier or quicker, but there is no enough evidence to prove this assumption with any certainty. What is clear is that some manufacturers even produced larger sheets of glass. For instance, the 1885 Antwerp World Fair catalogue mentions that the *Verreries de Jemappes* supplied window glass of 'regular and large dimensions', sheets measuring up to 2.7 m x 1.5 m, of 'simple, demi-double, double et triple' thickness.[1305] This corresponds to a sheet measuring about 155 'united inches', hence much larger than what was described by Lefèbvre as the maximum 'practical' size of manually blown window glass. While it can be assumed that the large sizes (above 80 'united inches') were certainly more difficult to produce, they were by no means impossible. Interestingly, a curious material artefact attests to this. It is a glass cylinder measuring 2.5 m in length and 40 cm in diameter, which was blown by Fernand Lecocq and Victor Declecq of the aforementioned *Verreries de Jemappes* in 1925, just before the termination of the manual production at this factory. If flattened, it would have resulted in a sheet of glass of about 2.5 x 1.25 m, or about 138 'united inches' (92 x 46). While somewhat smaller than the maximum size mentioned in the 1885 catalogue, it was still significantly larger than 80 'united inches'. Yet this particular cylinder was never flattened, as it was preserved in the local library of Jemappes as a kind of souvenir, attesting to the old craftsmanship.[1306]

Special and coloured glass

Clear ('white' or colourless) window glass amounted to the lion's share of Belgian window-glass production. For instance, for the period between 1907 and 1911, the exports of clear window glass amounted to the value of 34,208,679 Belgian francs, that of special glass to 245,759 Belgian francs and of coloured glass to 126,584 Belgian francs (note that these numbers relate to the exports, not the total production; no figures for the total production are known). Hence, the special and coloured glass together amounted to less than 0.7% of the total exports of window glass.[1307]

Nevertheless, despite the seemingly (quantitative) insignificance, the special and coloured glass cannot be omitted all together if we are to understand the Belgian window-glass industry. The questions of specialisation or standardisation are especially relevant in this respect, as they can define the organisation of the entire industry.

Even if the special and coloured glass can be regarded as a niche product, its significance can still be attested to by the mention of it at World Fairs and other expositions, as well as by the fact that many factories mentioned it explicitly in their letterheads, as will be shown later.

'Special glass' included a wide range of products. Not all of them meet the criteria of this research (that is, glass intended for the glazing of windows and produced by blowing). For

[1305] *Exposition Universelle d'Anvers. Catalogue Officel Général*. Tome I (Antwerp: n. p., 1885), catalogue nr. 675
[1306] Bruno Van Mol, "Actualités – quelques souvenirs des verreries de Jemappes"
[1307] A. Lalière, "Les industries du verre," III. 6, 19.

example, the products of *Verreries Fauquez*, such as *marbirte* (an imitation marble) will not be included, as they were used as a decoration rather than a glazing material.[1308]

Coloured and opal glass

For a long time, a large portion of all window glass produced was coloured unintentionally due to impurities. As mentioned at the beginning of this chapter, the lowest qualities of glass were designated as *verre commun* or *verre vert* (greenish glass), while the higher, (more or less) colourless qualities were described as *verre demi-blanc* and *verre blanc*. In this case, colour was undesirable, and this kind of lower quality 'green glass' largely disappeared from the sources from approximately 1850 on, as the four-qualities classification became established. However, the 'green glass' was still being produced in the 1850s as special glass for greenhouses (designated as *verre vert pour les serres*). In 1848, its price was equated to that of the 3rd-choice window glass.[1309] This kind of low-quality greenish glass for glasshouses, described as 'green glass for horticulture' (*verres verts pour horticultures*), was still produced by one Belgian factory, *Verreries du Bois Deville* (Émile Georges et frères), in 1907.[1310]

The intentionally coloured glass had been produced and used in present-day Belgium since the Middle Ages for stained windows. As mentioned previously, the 'secret' of the production of coloured glass was reintroduced in Belgium by Dominique Jonet around 1839.[1311] In the 19th century, various compositions for the production of coloured glass were known in Belgium. In the early 20th century, Belgian industry produced coloured glass 'of all desired shades'. Opal glass of various shades (white, blue, green, etc) was produced in Belgium at that time as well.[1312]

Other types of special glass that were mentioned in 1848 already, are the *verre cannelé* (fluted glass) and *verre mat*.[1313] The production method for coloured and opal glass did not differ much from that for ordinary clear window glass, except for the composition, obviously. The fluted glass was produced by blowing glass into a mould with grooves on its interior surface.[1314]

Rolled plate glass

[1308] Liesbeth Dekeyser and Claire Fontaine, "Een kennismaking met marbrite Fauquez, een Belgisch art deco opaalglas," *Bulletin Beroepsvereniging voor consrvators-restauratuers van kunstvoorwerpen vzw* 3 (2012, 3[e] trimester): 20-26.
[1309] Private archive Gobbe, Association, Originaux A, 28 novembre 1848, Assemblée de verriers des environs de Charleroy
[1310] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre,* 233-236.
[1311] Autobiographical manuscript by Léopold De Dorlodot, original preserved in the private archives of the De Dorlodot family, reproduced in M. Belvaux, *La famille (de) Dorlodot,* vol. 1, 288-289.
[1312] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre,* 156-157.
[1313] Private archive Gobbe, Association, Originaux A, 28 novembre 1848, Assemblée de verriers des environs de Charleroy
[1314] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 80-81.

Rolled plate glass goes beyond the topic of this study, strictly speaking, as it was produced by other processes than (manual) blowing. Nevertheless, a brief mention is appropriate here because some window-glass factories engaged in the production of such glass as well.

The production process consisted of casting molten glass from a furnace on a casting plate and rolling it to obtain a plate. The process resulted in translucent rather than transparent glass. While less suitable for ordinary glazing, this type of glass was preferred for some specific conditions where no direct vision was required, such as skylights or in order to ensure privacy. Moreover, by using a roller with an engraved pattern, a decorative pattern could be imprinted on the glass plate as well. In England, such glass was commonly known as cathedral glass and was introduced in the second half of the 19th century.[1315]

This kind of decorative imprinted glass was produced in Belgium in the early 20th century, if not earlier. The *verre antique ou cathédrale* (antique or cathedral glass) was described as 'irregular glass produced by cooling in contact with a roller'. Other types of imprinted rolled glass were known as *verre stiré, verre losagné*, etc, depending on the pattern.[1316]

Engraved glass

Last but not least, 'special' (or decorated) glass could be obtained by the engraving of ordinary clear window glass.

Engraving by means of sandblasting was a popular technique in Belgium in the early 20th century. Here, various types were distinguished. *Verre mat* was an even matt glass. *Verre mousseliné* presented a transparent ornament upon a matt background. Lastly, *verre givré* resembled frost patterns on glass.[1317] Acid engraving was another decoration method for window glass at that time.[1318]

Specialisation and organisation of production

Did the production of special and coloured glass imply 'flexible specialisation' in the industry, or were other strategies and mechanisms, such as standardisation, dominant? First, the degree of specialisation of individual firms will be analysed.

While some firms produced both types (ordinary window glass and special and/or coloured glass), others were specialised in special and coloured glass only. The Belgian-made special glass gained international recognition through the world fairs. For example, visitors to the 1878 Paris world fair could admire the 'imitation of ancient glass for churches' (most probably the cathedral glass) by *Verreries de Dorlodot et Cie* (Lodelinsart) or various types of coloured and special glass by *S.A. des Verreries Nationales* (Jumet).[1319]

[1315] Cable, "The Development of Flat Glass Manufacturing Process," 37.
[1316] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 68, 144-150.
[1317] Ibidem, 123.
[1318] Ibidem, 126.
[1319] *Exposition universelle de Paris 1878. Section belge. Catalogue officiel. Les Œuvres d'Art, des Produits de l'Industrie et de l'Agriculture*. 2[d] ed. (Brussels: Vandenauwera, s.d.), 82-85 ; Clovis Lamarre, *La Belgique et l'exposition de 1878* (Paris: Ch. Delgrave, 1878), 252.

The letterheads of various firms can provide further information in this respect. To provide only a few examples[1320]:

- *Verreries Belges* (Jumet) produced coloured glass, opal glass, as well as *mousselines*, *mats*, *cannelés* alongside ordinary clear window glass
- *Verreries des Hamendes* L. L. Lambert (Jumet) mentioned *verres mats*, *colorés* & *mousselines* alongside (ordinary clear glass) of 'great dimensions' as well as glass for photography
- *Verreries de la Marine* (Jumet) mentioned clear and coloured glass
- *Verreries de Jumet* mentioned *blanc* and *extra-blanc* clear window glass as well as coloured, *mats*, *mousselines* & *cannelés* and special glass for photography

A list of all active Belgian window-glass factories with their types of production, published in the *Fabrication et travail du verre* in 1907, provides us with relevant information in a more systematic way, so the following listing can be made[1321]:

- Factories producing ordinary clear window glass only (14): *Verreries D. Jonet, Verreries de l'Ancre réunies, Nouvelles verreries de l'Étoile, Verreries de Jemappes, Verreries de Mariemont, Verreries de Lodelinsart, Verreries Gobbe-Hocquemiller, Verreries Desgain frères, Verreries Goffe et fils, Verreries de Courcelles, Verreries des Piges, Verreries Schmidt-Devillez, Verreries du Long-Bois, Verreries de Tilly*
- Factories producing ordinary clear window glass alongside glass for photography, engraving, etc (5): *Verreries de Jumet, Verreries Bennert & Bivort, Verreries de la Marine, Verreries d'Anvers, Verreries Henri Lambert et Cie*
- Factories producing ordinary clear window glass alongside coloured and special glass (4): *Verreries Belges, Verreries de Hamendes, Verreries Léon Mondron, Verreries de Binche*
- Factories producing coloured and special glass only (2): *Verreries de l'Espérance, Verreries Émile Georges et frères*

The list contained 27 factories, yet two (*Verreries de l'Étoile* and *Verreries Henri Lambert et Cie*) were listed as inactive, while the type of their production was not mentioned. Of the 25 active factories, an absolute majority (19) produced clear window glass only, or clear window glass with glass for photography and other special uses, while only a minority of six factories produced coloured and special glass exclusively or coloured and special glass alongside clear window glass. As for location, only one 'special glass' factory, *Verreries de Binche*, was located outside the Charleroi region.[1322]

After the introduction of tank furnaces in the 1880s, the pot furnaces remained in use for the production of coloured and window glass only.[1323] The logic behind this development can easily be understood, as the coloured and special glass was produced in much smaller quantities (smaller batches), as already mentioned in this chapter. Hence, this technological

[1320] Letterheads, late 19th-early 20th century, reproduced in Plaude and Thomas, *La verrerie, une ruche humaine?* 6-7.
[1321] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 233-236.
[1322] Ibidem, 233-236.
[1323] Ibidem, 43.

development led to a further specialisation within the window-glass industry; from the 1880s on, different types of production equipment (tank furnaces or pot furnaces) were used for the production of ordinary clear window glass, or coloured and special window glass.

It can be concluded that specialisation was certainly present in the context of special and coloured glass. However, the *Association*'s proceedings attest to the fact that this specialisation was an exception, as the majority of the window-glass industry in the Charleroi region followed quite a distinct strategy as regards the standardisation of production.

This standardisation appeared in the *Association*'s proceedings from the very beginning in 1848 in conjunction with the fixing of prices and tariffs for foreign markets. Indeed, in order to set prices for a certain type of product, an agreement (whether voluntary or mandatory, formal, semi-formal or informal) on the key features needed to be achieved first. In the case of window glass, these features included qualities, dimensions and thickness. It seems that the four-qualities system was accepted silently from the establishment of the *Association* in 1848 onwards, as already discussed in this chapter.

The first explicit proposition for the standardisation of production was recorded in 1850, when Dominique Jonet proposed setting an equal thickness for the first three qualities of glass on the basis of the weight of glass produced by the *Société Nationale Frison & Cie*. It seems, however, that this proposition did not engender interest, as no further discussion followed.[1324]

Nevertheless, the example set by the '*Société'* became mandatory for various aspects of glass production shortly after. In 1850, it was adopted for the prices of the 1st and 2nd qualities, in 1851, for the manner of packaging the crates containing 50 square feet of glass, and for the prices of the 3rd quality as well.[1325]

It is not exactly clear which '*Société*' was meant, possibly the aforementioned *Société Nationale Frison & Cie* or the *Société des Manufactures*, which exploited the *Verreries de Mariemont*, the largest window-glass factory at that time. At any rate, it seems clear that the *Association* strove for unification on many aspects of glass production, such as prices, product properties such as dimensions, and even the manner of packaging (apart from this, unification of labourers' tariffs took place as well, see chapter on the organisation and control of labour). Here, a leading manufacturer exerted an influence by the power of example, which was, apparently, seen as a 'best practice' and even adopted as a standard. This can be seen as an example of interconnectedness within the district.

Paradoxically, this is quite contrary to the 'classical model' of an industrial district, whereby the flexible specialisation (hence, variation in product properties) is regarded as a norm. In our view, this paradox can be explained by the 'generic nature' of the product. As already mentioned, the classification into four qualities (choices) became a *de facto* international standard from approximately 1850 on. Moreover, as the window glass was a mass-export product, which was traded on a global scale whereby clients could be located in other

[1324] Private archive Gobbe, Association, Originaux A, Séance 4 juin 1850
[1325] Private archive Gobbe, Association, Originaux A, Séance 5 novembre 1850, Séance 11 mars 1851, Séance extraordinaire 18 mars 1851

countries or even continents, there was, presumably, only limited contact between clients and manufacturers (notwithstanding the fact that some manufacturers had their own agents and other representatives in other countries). In those circumstances, it was, speculatively, more important to assure general standardisation, so that clients on the other side of the world could be sure of what they were buying, than to adapt to specific requirements of various clients, as the 'flexible specialisation' theory postulates. This still left 'creative space' for individual enterprises, as attested by the reports from World Fairs and other expositions, where products were distinguished by the 'brilliance' (literally and figuratively) of their products.

Some aspects of production remained non-standardised as well. For instance, in 1882 it was proposed to introduce regulations on the thickness of window glass, especially for the sales in France and Italy. Nevertheless, this proposal was rejected.[1326] Moreover, the manufacturers guarded their own 'factory brands' (*marques de fabrique*), which were used to mark the glass. For instance, in 1881, a list of 'factory brands' of all members was composed by the *Association* and was to be sent to the Belgian consuls abroad.[1327] In 1909, the Belgian consul in Yokohama informed the *Association* that manufacturers wishing to protect their brands in Japan should deposit these marks at the Tokyo patent office.[1328] Apparently, despite the 'generic' nature of the product, the 'brand name' of a specific manufacturer still mattered.

A distinct, specific niche emerged of coloured and special glass emerged within the window-glass industry as well. Just as was the case for the production of ordinary window glass, most of these specialised firms were located in the Charleroi region. This niche did resemble the 'flexible specialisation' model much more. Presumably, it was directed towards the national rather than global market, as advertisements were placed in the local press, and publications such as trade directories. For example, a local trade directory *Guide industriel du Pays de Charleroi, Basse-Sambre Centre et Borinage* published in 1911, contained advertisements of several factories producing special glass.

For example, the firm of Jacques Lecomte-Falleur from Jumet was specialised in *verres spéciaux coulés* (special cast glass), such as *stiré, matelé, catéhdrale, imprimé, sablé, losagné, diamanté, métallifié*, etc. Despite not falling within the scope of the present study, this example is worth mentioning because it illustrates the development of very specialised production within the district alongside 'generic' clear window glass. Another firm mentioned in the *Guide industriel* was *Verreries du Hainaut Lerminiaux & Lemal* (Dampremy). Here, they specialised in the decoration techniques of window glass, such as *gravure à l'acide artistique et commerciale, enseignes décoratives, enseignes lumineuses, peinture et dorure des verres et glaces, vitraux d'art mise en plomb et en cuivre, revêtement de murs en verre opale*. This firm appears to have been a decoration workshop without its own glass production, but it is nevertheless relevant as it shows how 'generic' window glass could be customised by specialised firms situated within the district, thus in a way closing the gap between the standardised mass production and flexible specialisation. [1329]

[1326] Private archive Gobbe, Association, Originaux C, Séance 14 janvier 1882
[1327] Private archive Gobbe, Association, Originaux C, Séance 8 décembre 1881
[1328] Private archive Gobbe, Association, Originaux D, Assemblée Générale 13 décembre 1909
[1329] Hallet, *Guide industriel du Pays de Charleroi, Basse-Sambre et Borinage*, 32-41, 70, 39.

The decoration and other post-processing of glass carried out by specialised firms that did not produce the glass themselves can be added to this. However, they were generally located in large cities such as Brussels and Antwerp, possibly due to the proximity of clients (architects, building contractors). Nevertheless, the majority of such firms were located in the region of Charleroi as well (see discussion of the input-output transactions as a type of Marshallian externalities in Part 2). While not being glass manufacturers *strico sensu*, these firms certainly contributed to the flexible specialisation of the district as a whole. An example of an (apparently) particularly important window-glass decoration firm located within the district was the *Société anonyme Verreries de l'Hermitage* of Jumet ('previously known as E. Masquelier' according to the *Fabrication et travail du verre*). Despite the designation '*verreries*', which was normally reserved for those firms that produced (melted) glass themselves, this firm appears to have been specialised in the decoration and 'post-processing' of glass produced by other firms. The *Fabrication et travail du verre* mentions it within the category of 'Auxiliary industries' (*Industries accessoires*) rather than the main category of glass-producing firms. In 1907, its activities were described as sand engraving of window glass (*mousseline* glass), sand engraving and painting on *marmorite* ('special glass' imitating marble) for advertising boards, acid engraving on clear and coloured window glass, cut glass as well as *verres bombés* for furniture, showcases and other uses, enamelled glass and even 'imitation of stained glass with coloured enamel for churches, monuments and apartments'.[1330] This firm was mentioned in the aforementioned *Guide industriel* as well, where it was described as offering *vitaux d'art, vitraux en cuivre, gravure sur verre, enseignes decoratives and revêtement de murs*.[1331]

In these cases, presumably, the distance between the client and manufacturer was much shorter, so that the latter could quickly adapt to the specific wishes of the former, as postulated by the flexible-specialisation model. Hence, the presence of specialised firms directed towards more specific demands, whether they produced their glass in-house or merely post-processed (decorated) clear glass produced by other firms shows that flexible-specialisation was present in the district as well. Nevertheless, it should be kept in mind that the largest share of total production consisted of 'generic' standard clear window glass intended for export all over the world. Hence, even if specialised firms were catering for the special needs of relatively nearby clients according to the flexible-specialisation model in the district as shown above, this was a niche element that did not define the organisation of the district in general.

The main organisational model remained that of uniformisation and standardisation. This goal could be achieved (or, at least, approached) by the actions of the *Association*. In a way, the multitude of small enterprises could achieve the same advantage as one large enterprise. Yet it is important to know that a leading manufacturer (*Société*) played an important role by setting an example. Larger enterprises were reluctant to join the *Association* in the first decades of its existence.

[1330] Ministère de l'Industrie et du Travail. Office du Travail, *Fabrication et travail du verre*, 243, 250, 252.
[1331] Hallet, *Guide industriel du Pays de Charleroi, Basse-Sambre et Borinage*, 139.

Conclusion Part 3

It is now possible to return to the questions formulated in the introduction to this part of the thesis.

The *first question* (how did the knowledge community come into being and develop within the context of a small region?) can be answered as follows. The community emerged due to the immigration of skilled workers as well as entrepreneurs to the region of Charleroi and Centre during the 16th, 17th and, especially, 18th century. Located within a small region, this community developed a network of local ('buzz') as well as international ('pipeline') relationships. The community actively engaged in the exchange of knowledge by means of personal mobilities (mass migrations as well as individual itineraries), acting as receiver as well as donor of knowledge.

The *second set of questions* (how was the knowledge further developed and managed within the district? Which strategies were employed? Did specific knowledge-management strategies emerge?) can be answered as follows. Patenting was a widely used strategy. The popularity of this strategy is attested by the numerous 'trivial' inventions patented. The high propensity to patent can be explained by the low threshold of the Belgian patenting legislation as well as a cultural openness to patenting. It can also point to the perceived sense of economic value of an invention, as something that could be traded. However, the propensity to patent varied according to the type of knowledge, which was highest for 'thermal knowledge' (melting furnaces and annealers) and lowest for 'chemical knowledge' (components and recipes). With respect to geography, the quantitative analysis attests to the strong local embeddedness of the inventive activity related to window glass, which was concentrated in the region of Charleroi itself, suggesting a strong connection between practice and innovation. Brussels acted as a 'innovation gateway' through which foreign patents were 'imported'. Therefore, Brussels can be seen as a market for invention. It seems that, in general, patenting was accepted and respected by the community. However, on a few occasions, patenting was contested (as exemplified by some legal cases), whereby a kind of notion of 'public domain' (innovation belonged to everyone) emerged. In general, however, the community was reluctant to share its knowledge with outsiders through publications until the early 20th century. That said, a certain amount of informal information sharing and learning certainly occurred within the community. Nevertheless, the collective-invention arrangement did not emerge due to the lack of a publishing culture. By the early 20th century, the *Association*, as the most important governing body, started to engage actively in the technology transfer from foreign countries, yet without practical results. Moreover, patenting by Belgians started to lag behind foreigners by the early 20th century.

The *third question* (how was the innovation put into practice and how was it related to craftsmanship?) can be answered as follows. The glass-making region and community of Charleroi continued to actively innovate throughout the entire period. Instead of a few isolated 'milestones', we witness a sequence of long waves of innovation related to various aspects of glass technology. The technological creativity was always present, with peaks around 1850s and 1860s (the development of annealers) and 1880s (the development of melting furnaces). The innovations in window-glass technology were interlinked with general trends of industrial development in Belgium (such as the first and second Industrial

Revolution), albeit arguably to a lesser degree than many other industries. Nevertheless, the 'traditional' craft skills remained of essential importance as well. Hereby, the control of 'property of skill' became a matter of dispute between the workers and bosses. Despite its success during the largest part of the 19th century, the system started to became obsolete by the late 19th and early 20th century in social perspective, as it relied heavily on child labour, which was regarded as absolutely necessary for the development of the aforementioned skills and, hence, the survival of the entire production system.

The *fourth and final question* (how did the product change due to the aforementioned developments?) can be answered as follows. The technological innovations were of a largely quantitative influence, as they were mostly aimed at cost reductions (notably, fuel economy). However, some innovations also influenced the quality of the glass, e.g. tank furnaces that allowed for more regular glass melting. The introduction of artificial soda had a positive effect on the quality as well, as it allowed for the production of ordinary window glass of the same quality as the old potash-based *verre de Bohême*. Nevertheless, craftsmanship remained essential in a qualitative sense, as the glass quality depended heavily on the glassblowers' skills. Possibly, some de-skilling occurred due to the introduction of tank furnaces. Interestingly, the characteristic of window glass as a largely 'generic' product had led to a specific organisation of production within the district, whereby standardisation (rather than flexible specialisation) was preferred. Only within the small niche of coloured and special glass, does the flexible specialisation-organisation seem to have been present.

In general, it can be concluded that the entire industrial district started to show signs of a systematic crisis by the early 20th century, which was apparent in both a technological (lagging behind in patenting activity) and a social (reliance on child labour) sense. The *Association*, which acted as the main governing body, seems to had been (implicitly) aware of these problems, and it started to take measures. Concerning the former problem, the *Association* started to promote technology transfer from foreign countries (implicitly admitting that Belgium was falling behind). As for the latter issue, the *Association* lobbied actively against social legislation, striving towards the preservation of child labour, which was represented almost as a cornerstone of the entire production process. Nevertheless, both strategies ended in failure, because the *Association* did not succeed in importing any foreign technology, and child labour just could not be maintained in the long run.

The situation was 'saved' by one man, Émile Fourcault, who developed a revolutionary system for the mechanical production of glass. He mostly acted on an individual basis, despite being a member of the *Association*. Which is to say that, paradoxically, one person succeeded where the entire community failed.

General conclusion

This study has explored various aspects of the history of the Belgian window-glass industry in the 19th century, ranging from the development of technology to international representation. Given that almost the entire window-glass industry remained concentrated in the Charleroi region during the period under consideration, this study fits into the historiography of industrial districts. Indeed, the theory of industrial districts was deliberately chosen as a main theoretical framework. The conclusion will bring various aspects together, integrating them into the broader framework offered by the theory of industrial districts. This will allow for connections to be made between these aspects, and provide an understanding of the historical development of the district in its entirety.

The elaboration of the conclusion itself will proceed in three steps. First, the key characteristic (or features) of the district, already discussed in the partial conclusions in the previous parts, will be recapitulated concisely in the framework of the industrial-district theory. While some of these features are in line with previous international research on industrial districts, others are rather unique. These unique features, which set the Charleroi window-glass district apart, will be discussed in more detail. They are especially interesting as they provide a comparative contribution to the historical diversity of industrial districts. Specifically, the empirical research findings will be 'entered' into two analytical models: the 'four-quadrant model' and the Modified adaptive system model. In this way, various aspects will be brought into a broader theoretical context. This will allow for a better understanding of the historical development path of the district and some of its characteristics. Finally, the three research questions will be addressed.

Key features and characteristics of the Charleroi industrial district

In order to assess the degree to which the window-glass region of Charleroi conformed to the 'classical' model of industrial districts, and what particular features set it apart, we can now return to the definitions of industrial district that have been formulated over the years. To begin with, the classical Marshallian district emphasised knowledge creation and sharing within the district, as well as the special role of 'hereditary skills' (*the industrial atmosphere*). Furthermore, Marshall distinguished three types of externalities (later designated as Marshallian externalities), i.e. input-output transactions, labour market pooling and technological externalities. Of these, labour market pooling was undoubtedly the most relevant for the Charleroi case. It can now be stated that the highly specialised pool of glassblowers remained the main defining characteristic of the district until the early 20th century. Two other Marshallian externalities, while certainly not completely absent, were of much lesser importance. The defining role of the labour market pool further attests to the lasting importance of the 'hereditary skill'.

Further developments of the industrial-district theory (the 'New Industrial Districts', rooted in the work of Michael E. Porter) placed more stress on innovation, knowledge creation, long-range knowledge exchange ('pipelines') and the role of institutions and organisations. All of these aspects are well represented in the case of the Charleroi district. To begin with, my research shows that (contrary to the opinion represented in older literature), the district proved to be an 'innovation hub' during the largest part of the period under consideration.

Yet, by the late 19th century, the innovative activities started to lag behind foreign developments. Interestingly, no collective-invention arrangements (as defined by Robert C. Allen) emerged in the Charleroi region, yet other collective knowledge-management mechanisms were present. The *Association des maîtres de verreries*, the business-interest organisation of the window-glass industry, was particularly active in this field, albeit only in the later period. In general, the role of this organisation was remarkably prominent, especially considering international contacts (which can be interpreted as 'pipelines') from the last quarter of the 19th century on. These international activities by the *Association* concerned the exchange of commercial information, international promotion and exploration of new markets alongside technological innovation. To that end, the *Association* collaborated with the Belgian government, the Ministry of Foreign Affairs in particular, including the consular network. The important role of the *Association* and the establishment of 'pipelines' can be regarded as an important feature of the Charleroi industrial district. The *Association*'s efforts towards the establishment of 'pipelines' were, presumably, of particular importance for smaller firms, which did not have the resources to maintain international contacts on their own. Hypothetically, it can be assumed that these 'pipelines' were especially important for a district specialised in the very export-oriented production such as window glass, yet more comparative research with other Belgian regions and industries is necessary to test this hypothesis. The Charleroi district can be described as 'horizontal' in the terminology of Zeitlin, as the 'horizontal dimension' (firms producing similar products) dominated.

Another 'remarkable absence' alongside the collective-invention strategies, is the flexible specialisation, generally regarded as typical for the industrial districts. Except for the niche of coloured and special glass, no indications of such a strategy are noticeable. On the contrary, standardisation of production seems to have been a preferred strategy.

When balanced out, it can be stated that the Charleroi district can be regarded as a Marshallian district because at least one of the three Marshallian externalities (labour market pooling) was strongly present. Technological externalities were prominently present as well, as exemplified by the many technological developments that were made in the district. While input-output externalities were of lesser importance, the 'hereditary skills' were very relevant, too. The great importance of international connections ('pipelines') is an interesting particular feature of the district, which even makes it similar to the 'New Industrial Districts' of the second half of the 20th century to some degree. In summary, the following particular features of the Charleroi district can be distinguished: the absence of flexible specialisation, the low importance of the input-output externalities, the great importance of 'pipelines' and the absence of the collective-invention arrangements. They clearly set this district apart from the 'classical Marshallian district', emphasising the diversity of the phenomenon of industrial districts.

As to the question of which factors explain these specific characteristics, I will limit myself to a few hypotheses. The absence of flexible specialisation (except for the coloured and special glass niche) can arguably be explained by the intrinsic characteristic of window glass as a standardised product. Despite having variation in qualities, it remained a largely 'generic' product, especially when compared to textiles or pottery products, which were very much influenced by changing fashions and consumer preferences. In these circumstances, assuring standardisation must have been a preferable strategy, so that clients were sure of what they were buying. The specific production process of window glass was in all likelihood the reason for the very limited role of input-output externalities. With the exception of some decoration and post-processing activities, such as glass engraving, the production process could not be divided between various firms. The importance of 'pipelines' can be explained by the export-oriented character of this industry, as its commercial network encompassed the whole world. The absence of the collective-invention arrangements is more difficult to explain. Arguably, it could be due to the individualistic mentality present within the community.

Analysis of the district's development on the basis of two models

The 'four-quadrant model'

The 'four-quadrant model' provides a matrix for the structure and governance of a district depending on the combination of resource bases and resource dependency. The model can explain the changing structure of a district, as this combination might change over time.

Figure 17: Four-quadrant model of industrial districts

		Resource dependency: High	Resource dependency: Low
Resource base	Extensive	**Quadrant 2** Hierarchical, centralized	**Quadrant 3** Hierarchical, decentralized
	Narrow	**Quadrant 1** Heterarchical, centralized	**Quadrant 4** Heterarchical, decentralized

Source: Popp, Toms and Wilson, "Industrial districts as organisational environments," 360

To apply this model to the case of the Charleroi industrial district, resource bases and resource dependencies should be assessed. The resource-dependency axis is the easiest to assess. It stands for the (external) capital. Here, the introduction of the tank furnace in the 1880s marked a clear shift, as this piece of equipment required large amounts of capital. Hence, the organisation shifted from 'low resource dependency' to 'high resource dependency' at that time.

The assessment of the resource base is much less straightforward. It defines whether the situation of the Charleroi district fits in Quadrant 3 or Quadrant 4. The 'narrow' resource base stands for specialised resources, the 'extensive' for generic resources. In the case of Charleroi window glass production, the raw materials and fuel were extensive resources. The role of labour is much more difficult to assess. The specialised labour of glassblowers was certainly exclusive, because, with very few exceptions, this skill was found only within the Charleroi district. On the national level, the glassblowers' skill could certainly be regarded as a narrow resource. Yet, within the district itself, the picture is less straightforward. It seems that, as window glass was a rather generic product with few variations, the glassblowers' skills must have been relatively similar. It can be assumed that the production of special glass required more specialised (i.e. 'narrow') skills on the part of glassblowers, but we do not possess any explicit information in that respect. The only plausible special skill (in contrast to the 'generic' skill of the window-glass blowers) is that required for the production of very large pieces of glass (larger than 80 'united inches').

It can, therefore, be concluded, that the Charleroi district transitioned from Quadrant 3 to Quadrant 2 in the last quarter of the 19th century. According to the theory, firms within Quadrant 3 tend to show little diversity in their activities with few tendencies towards an oligopolistic situation (dominance of a few larger firms). In other words, the structure of the district is horizontally fragmented, with many firms of similar size engaging in similar activities. Overall, the positive effects associated with industrial districts tend to be less prominent in this configuration. The role of governance institutions in such an environment is often directed towards the control of competition between firms, while the sharing of information can be promoted by governance as well.[1332] This is indeed reminiscent of the situation observed in the Charleroi region. While specialisation was not entirely absent, it remained largely limited to the niche of special and coloured window glass. Despite the presence of large firms, such as *Bennert & Bivort*, there was little if any tendency towards oligopoly. The arrangements for limiting production (*chômage*) by the *Association* are in accordance with the model as well. The shift to Quadrant 2 entails the growth of firms in size, while they remain rather generic in their activities.[1333] The situation observed in Charleroi is again in accordance with this.

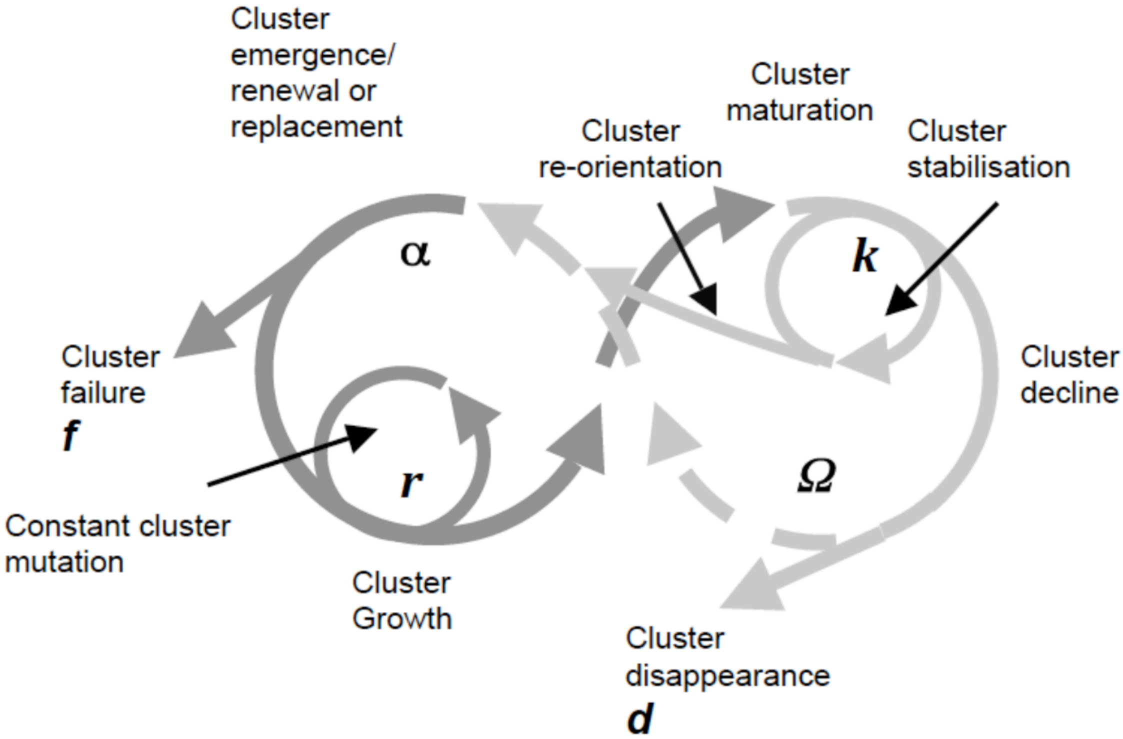
All in all, the 'four-quadrant model' explains why the district lacked some of the features associated with 'classical industrial districts'. In particular, the governance organisations in districts with extensive resource bases tend to be rather limited in their field of action, while these of districts with narrow resource bases generally play a larger role in the coordination between firms.[1334] In Charleroi, the *Association* did, indeed, not interfere much in the internal affairs of member firms, proclaiming, at least rhetorically, the liberal principles of non-interventionism.

The Modified Adaptive System model

The Modified Adaptive System model presents six possible trajectories for the development of industrial districts. Hereby, the adaptation of the district is regarded in a non-deterministic way, as the ultimate path followed is defined by the multitude of decisions taken by firms in the district. For instance, efforts undertaken by firms and individuals in the area of innovation can help a district to undergo a revival instead of a decline.[1335]

[1332] A. Popp, S. Toms and J. Wilson, "Industrial districts as organizational environments: Resources, networks and structures", *Management & Organizational History*, 1:4 (2006), p. 349-370
[1333] Ibidem
[1334] Ibidem
[1335] R. Martin & P. Sunley, "Conceptualizing Cluster Evolution: Beyond the Life Cycle Model?"

Figure 18: Alternative cluster evolutionary trajectories according to the Modified cluster adaptive cycle model



Source: Martin and Sunley, "Conceptualizing Cluster Evolution," 1312

In order to assess which of the possible trajectories presented by the model was followed by the Charleroi district, the main development stages of the district need to be summarised briefly. The *emergence* of the district can be situated around 1750, when the window-glass industry started to concentrate in the region. After this, the industry experienced steady growth (despite occasional setbacks) up to the 1870s and 1880s. In this process, several important innovations were introduced, such as the switch to coal as a fuel, the introduction of new types of annealers and the switch to artificial soda. The most important innovation was the introduction of the tank furnace in the 1880s. As already discussed, the district has shown a clear ability for almost continuous innovation and creativity. This innovation and creativity contributed to the resilience of the district.

The transformation caused by the introduction of tank furnaces was especially profound. This can be seen as the *constant mutation* of the district. However, certain indications of growing rigidities and possible lock-ins started to appear in the late 19th century. The inventive activity declined, while the district started to fall behind foreign competition as far as the introduction of mechanical production is concerned. Yet the introduction of the mechanical production method by Fourcault allowed them to avoid the emerging lock-in and moved the entire district into a new phase of *constant mutation*. These developments are beyond the chronological scope of this study, as they largely occurred after the First World War. Nevertheless, it is worth noting that the district experienced very profound transformation after the introduction of mechanical production.[1336] Subsequently, the district went into

[1336] Poty and Delaet, *Charleroi pays verrier*, 171-205.

decline again after the 1960s, despite the introduction of the new float method.[1337] By the early 21st century, window-glass production (and the glass industry in general) in Belgium was all but gone, except for one research and development facility in Gosselies, owned by multinational group AGC in 2022.[1338] It can be seen as the last remnant of the once famous industrial district.

In summary, the industrial district followed the cluster disappearance trajectory (classic life cycle trajectory) of emergence, growth, maturation, decline and elimination. And yet, for a long time, the district experienced a phase of constant mutation that allowed it to live through several important transformations. The Modified Adaptive System model reaffirms the importance of technological creativity and innovation for the long-time survival of the district.

Research questions

Research question 1

How can the concentration of the window-glass industry in a small region be explained? In other words, which factors were responsible for the clustering of the industry?

The initial factors for the localisation of the window-glass industry in the Charleroi region from the mid-18th century (or even earlier) onwards were the availability of fuel (coal) in close proximity or even on site. This can be seen as primitive localisation in Marshallian terms. To this, the transport infrastructure (the Brussels-Charleroi road) can be added. These factors are important, but not defining. The determining factor was the arrival and settlement of skilled glassblowers in the region. This community, which possessed unique tacit knowledge and skills, remained rooted in the region until the 20th century. Throughout that time, the pool of highly skilled workers remained the primary defining characteristic of the region.

The importance of the sources of fuel and raw materials for the location of the industry diminished in the second part of the 19th century, when they were supplied from further away. In other words, the location of coal can partly explain why the industry settled in the region originally, but not why it remained there. Rather, the presence of a professional community should be seen as compound localisation in Marshallian terms. Other factors, such as the presence of suppliers of industrial equipment in the region, were of some importance, but cannot be seen as a decisive factor. It was only after the need for specialised skills was eliminated by mechanisation (the Fourcault and Libbey-Owens processes) that the industry could decentralise to other locations in Belgium closer to the raw materials (the

[1337] Ibidem, p. 291-321

[1338] Pierre Buchkremer and Maurizio Sadutto, "Gloire du passé industriel carolo, l'industrie du verre a-t-elle encore un avenir en Wallonie?", In: rtbf.be, published on 29.09.2022, accessed on 01.07.2023 via https://www.rtbf.be/article/gloire-du-passe-industriel-carolo-l-industrie-du-verre-a-t-elle-encore-un-avenir-en-wallonie-11075935

Campine area for sand) or transport infrastructure (Zeebrugge), and the Charleroi region lost its monopoly in this industry.

Research question 2

Did the clustering cause specific governance structures and arrangements, such as specific production organisation, predicted by the theory of industrial districts? If discrepancies between the theory and factual outcomes are observed, which factors can be held responsible?

The main governance structure (organisation) that emerged in the district was the *Association des Maîtres de Verreries*. This organisation had little influence on the functioning of individual enterprises, yet was particularly active on the international scene, establishing business connections and information-exchange channels ('pipelines'). For this, the *Association* could rely on the Belgian government and the Ministry of Foreign Affairs in particular, who provided support by engaging the consular network.

Instead of the flexible specialisation of production, closely associated with industrial districts, standardisation occurred, which is rather surprising. This can be attributed to the properties of the product, which was more 'generic' than most products associated with other industrial districts. Hence, the clustering certainly caused the emergence of specific arrangements, some aspects of which are rather distinct from what could be expected based on the industrial-district theory.

Research question 3

Did the clustering provide specific conditions for the development of innovation, such as (collective) knowledge-management strategies and how was this related to craftsmanship? If discrepancies between the theory and factual outcomes are observed, which factors can be held responsible?

It is clear that the district provided fertile ground for technological development and innovation. Many important innovations were developed here during the period under consideration. Here, the development can be represented as 'long waves' of continuous innovative efforts rather than a few isolated 'milestone inventions'. The inventive activity was firmly rooted in the region, as attested by the geography of patenting. Presumably, informal knowledge exchange ('buzz') played an important role in this process, although explicit mentions are almost absent from the sources at our disposal. At the same time, long-distance knowledge exchange ('pipelines') became increasingly important in the course of the 19th century. These observations are in line with the concept of 'New Industrial District' and the particular role of interaction between local knowledge creation within the district ('buzz') and knowledge exchange between the district and the outside world ('pipelines') as elaborated by Harald Bathelt et al. This observation poses an intriguing question about the degree to which the 'New Industrial Districts' with their emphasis on knowledge creation are truly 'new'. To address this question, more comparative research is needed.

Yet the Charleroi district did not develop the collective invention strategy as defined by Allen. Arguably, this can be explained by the individualistic attitude of at least some 'dissident firms'. At the same time, other collective knowledge-management mechanisms were practised. In particular, the *Association* made great efforts to acquire knowledge of the latest technological developments, although the implementation of this knowledge remained deficient.

The craftsmanship of glassblowers remained of paramount importance until the proliferation of mechanical production after the First World War. This craftsmanship was closely associated with the professional community that possessed the 'hereditary skill'. This community was exclusive to the region and can even be seen as defining for its limits.

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Séance 1 avril 1881
Séance 30 mai 1881
Séance 5 août 1881
Séance 22 août 1881
Séance 17 octobre 1881
Séance 11 novembre 1881
Séance 26 novembre 1881

Brouillons II

Séance 1 juin 1883
Séance 6 juin 1883
Séance 11 août 1883
Séance 24 septembre 1883
Séance 26 octobre 1883
Séance 21 décembre 1883
Séance 6 février 1884
Séance 8 février 1884
Séance 9 février 1884
Séance 16 février 1884
Séance 23 février 1884
Séance 12 mars 1884
Séance 17 mars 1884
Séance 21 mars 1884
Séance 24 mars 1884
Séance 7 avril 1884
Séance 2 mai 1884
Séance 15 mai 1884
Séance 25 juillet 1884
Séance 14 août 1884
Séance 22 octobre 1884
Séance 15 décembre 1884
Séance 7 avril 1884
Séance 20 avril 1885
Séance 15 mai 1885
Séance 21 mai 1885
Séance 27 juillet 1885
Assemblée Générale 27 juillet 1885 – Rapport sur la situation en 1884
Séance 9 octobre 1885
Séance 14 novembre 1885
Séance 20 novembre 1885
Séance 3 décembre 1885
Séance 12 avril 1886
Séance 23 septembre 1886
Séance 19 novembre 1886
Séance 17 décembre 1886
Séance 12 février 1886
Séance 12 avril 1886
Séance 19 novembre 1886
Séance 19 janvier 1887
Séance 16 février 1887
Séance 4 avril 1887
Séance 6 mai 1887
Séance 11 juillet 1887
Séance 1 octobre 1887

Séance 7 novembre 1887
Séance 21 novembre 1887
Séance 5 décembre 1887
Séance 24 janvier 1888
Séance 30 juin 1888
Séance 31 août 1888
Séance du 14 Janvier 1889
Séance du 22 Janvier 1889

Brouillons III

Séance 5 février 1892
Séance 3 janvier 1893
Assemblée Générale, 17 février 1893

Brouillons IV

Assemblée 12 septembre 1902
Assemblée Générale 15 septembre 1902
Assemblée 22 septembre 1902
Assemblée 10 octobre 1902
Assemblée 20 octobre 1902
Assemblée 22 décembre 1902
Assemblée 31 décembre 1902
Assemblée 19 janvier 1903
Assemblée 25 janvier 1903
Assemblée Générale 22 mai 1903
Assemblée Générale 8 juin 1903
Assemblée du Comité 12 juin 1903
Assemblées 25 et 26 janvier 1904

Rapport du Comité Spécial (inscribed between Assemblée Générale 23 octobre 1903 and Assemblée Générale 14 décembre 1903)

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Administration des mines, ancien fonds (further: ARA-Mines)

ARA-Mines, nr. 776
ARA-Mines, nr. 776, dossier verreries Zoude-Drion
ARA-Mines, nr. 776, dossier 712
ARA-Mines, nr. 776, dossier 992
ARA-Mines, nr. 776, dossier 1429
ARA-Mines, nr. 776, dossier 1671
ARA-Mines, nr. 776, dossier 1826
ARA-Mines, nr. 776, dossier 2057
ARA-Mines, nr. 776, dossier 2134

ARA-Mines, nr. 777
ARA-Mines, nr. 777, dossier Verreries Falleur, Lefèvre, Andris
ARA-Mines, nr. 777, dossier Verreries Roch
ARA-Mines, nr. 777, dossier 1669
ARA-Mines, nr. 777, dossier 1722
ARA-Mines, nr. 777, dossier 2899

ARA-Mines, nr. 778
ARA-Mines, nr. 778, dossier Verreries Delobel
ARA-Mines, nr. 778, dossier Verreries Depermentier
ARA-Mines, nr. 778, dossier Verreries Desandrouin
ARA-Mines, nr. 778, dossier Verreries Dorlodot-Levieux
ARA-Mines, nr. 778, dossier Verreries Falleur
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ARA-Mines, nr. 778, dossier 399
ARA-Mines, nr. 778, dossier 582
ARA-Mines, nr. 778, dossier 1665
ARA-Mines, nr. 778, dossier 2859

ARA-Mines, cartes et plans
ARA-Mines, cartes et plans, AK3641
ARA-Mines, cartes et plans, AK3648
ARA-Mines, cartes et plans, AK3662
ARA-Mines, cartes et plans, AK3665

State Archives of Belgium 2 – depot Joseph Cuvelier, Brussels (ARA-2)

Brevets d'inventions (Invention patents)

Only invention patents referenced individually are listed here. The complete list of patents used for the quantitative analysis is provided in the Appendix.

Brevet nr. AC 845 (1837)
Brevet nr. AC 878 (1837)
Brevet nr. AC 1133 (1838)
Brevet nr. AC 1408 (1839)
Brevet nr. AC 1428 (1839)
Brevet nr. AC 1359 (1839)
Brevet nr. AC 2148 (1842)
Brevet nr. AC 3652 (1846)
Brevet nr. AC 3888 (1847)
Brevet nr. AC 4423 (1848)
Brevet numéro indicateur 5573 (1848)
Brevet nr. AC 4623 numéro indicateur 5842 (1849)
Brevet nr. AC 5135 (1850)

Brevet numéro indicateur 799 (1855)
Brevet numéro indicateur 825 (1855)
Brevet numéro indicateur 830 (1855)
Brevet numéro indicateur 974 (1855)
Brevet numéro indicateur 984 (1855)
Brevet numéro indicateur 991 (1855)
Brevet numéro indicateur 992 (1855)
Brevet numéro indicateur 1038 (1855)
Brevet numéro indicateur 1434 (1855)
Brevet numéro indicateur 1539 (1855)
Brevet numéro indicateur 1682 (1855)
Brevet numéro indicateur 1933 (1855)
Brevet numéro indicateur 2105 (1855)
Brevet nr. 9118 (1860)
Brevet nr. 9502 (1860)
Brevet nr. 16573 (1864)
Brevet nr. 27088 (1870)
Brevet nr. 27649 (1870)
Brevet nr. 28187 (1870)
Brevet nr. 50309bis (1880)
Brevet nr. 52090 (1880)
Brevet nr. 52325 (1880)
Brevet nr. 52360 (1880)
Brevet nr. 52563 (1880)
Brevet nr. 53164 (1880)
Brevet nr. 53257 (1880)
Brevet nr. 61792 (1883)
Brevet nr. 69954 (1885)
Brevet nr. 89946 (1890)
Brevet nr. 147213 (1900)
Brevet nr. 151411 (1900)
Brevet nr. 150783 (1900)
Brevet nr. 151149 (1900)
Brevet nr. 153676 (1900)
Brevet nr. 182038 (1905)
Brevet nr. 223414 (1910)

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Chambre de commerce, dossier 343, Situation de l'a industrie verrière pour 1837
Chambre de commerce, dossier 343, letter by Houtart-Cossé (1835)

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Établissements classés (further: Établissements)

AvCh, Établissements, Dampremy (further: DA), dossier 698 Schmidt-Devillez (la Planche)

AvCh, Établissements, DA, BT 1, dossier nr. 37 Jules Frison
AvCh, Établissements, DA, BT 2, dossier nr. 58 Verreries d'Ancre
AvCh, Établissements, DA, BT 22, dossier nr. 698

AvCh, Établissements, Jumet (further: JU), BT 40, dossier nr. 1061, S.A. Verreries de la Marine
AvCh, Établissements, JU, BT 47, dossier nr. 1263, S.A. Verreries de Jumet (Verreries Nationales)
AvCh, Établissements, JU, BT 47, dossier nr. 1265 S.A. Verreries Bennert & Bivort
AvCh, Établissements, JU, BT 47, dossier nr. 1268, S.A. Verreries Belges
AvCh, Établissements, JU, BT 47, dossier nr. 1269, S.A. Verreries Bennert & Bivort
AvCh, Établissements, JU, BT 47, dossier nr. 1270, S.A. Verreries Belges
AvCh, Établissements, JU, BT 47, dossier nr. 1292
AvCh, Établissements, JU, BT 110, dossier nr. 3375
AvCh, Établissements, JU, BT 110, dossier nr. 3379
AvCh, Établissements, JU, BT 110, dossier nr. 3383
AvCh, Établissements, JU, BT 114, dossier nr. 3584
AvCh, Établissements, JU, BT 117, dossier nr. 3730
AvCh, Établissements, JU, BT 118, dossier nr. 3736
AvCh, Établissements, JU, BT 226, dossier nr. 7302, S.A. Verreries Bennert & Bivort
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Unclassified documents, document Verreries des Piges, 29 September 1916, no archive code
Unclassified documents, document Jules Arbé, no archive code
Unclassified documents, two notebooks:
'Thin' notebook, initiated in 1903, archive code DIV58
'Thick' notebook, initiated in 1910, no archive code

Divers
Divers, DIV 45
Divers, DIV 81

Verreries Pays de Charleroi 18^{e}-19^{e} siècle ('Charleroi' box)
nr. 8914/161/57, document Bennert Bivort (11 juillet 1871)
nr. 8914/161/59, document Bennert Bivort (20 juillet 1871)

Documentation centre of the Museum voor Oudere Technieken (Grimbergen, Belgium)

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Appendix patent sample

The present appendix provides the full sample of patents that was used for the graphs in the thesis. For the period 1830-1855, the patents are listed according to their AC-number or *numéro d'indicateur* (shortened to ind in the tables) when the AC-number could not be retrieved. For the period 1855-1910, the single patent number is provided.

After 1855, the patent number, which can be used to retrieve the file from the archive (ARA-2 Joseph Cuvelier) for consultation, was indicated in the *Recueil des brevets.* The matter is much more complicated for the previous period, as the *Catalogue des brevets* did not mention the patent number. Using the exact date of issue, which is indicated in the *Catalogue des brevets*, the number can be found in the (handwritten) lists that can be consulted through the archive website. In most cases, the AC-number can be found. This number can be used to retrieve the file. For some years, only the *numéro d'indicateur* can be found. Although less convenient, this number (in combination with the year of the patent) can be used to retrieve patent files as well.

Patents 1830-1840

Number	Year	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
AC544	1832	Perfectionnement	thermal/mechanical	annealer (patent is missing)	Houtart-Cossé	Haine-Sainte-Pierre					Centre	Belgium		
AC845	1837	Importation	thermal/mechanical	annealer	J. Frison	Dampremy	Andris					unclear (presumably foreign)	société Frison	Dampremy
AC878	1837	Perfectionnement	thermal/mechanical	turntable for annealer	J. C. Dams in name Société des Manufactires	Jumet					Charleroi	Belgium		
AC1133	1838	Invention	thermal/mechanical	annealer	J. Frison	Dampremy					Charleroi	Belgium		
AC1225	1839	Invention	unknown	process to make glass 'perfectly flat' (patent is missing)	Laroche	Brussels-city					Brussels	Belgium		
AC1359	1839	Perfectionnement	thermal/mechanical	improved annealer	J. Frison	Dampremy					Charleroi	Belgium		
AC1408	1839	Invention	thermal/mechanical	coal-fired annealer	Houtart-Cossé	Jumet					Charleroi	Belgium		
AC1428	1839	Invention	thermal/mechanical	new type of annealer	L. De Dorlodot	Charleroi-city					Charleroi	Belgium		
AC1613	1840	Invention	thermal/mechanical	new type of annealer with 'moving stones'	Société de St. Laurent, administrateur M. A. Deby	Brussels-city					Brussels	Belgium		
AC1675	1840	Perfectionnement	thermal/mechanical	improved annealer	L. De Dorlodot	Charleroi-city					Charleroi	Belgium		

Patents 1841-1850

Number	Year	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Locaton 2	Patentee 3	Locaton 3	Region	Country	Belgian representative	Location representative
AC1852	1841	Invention	thermal	melting furnace	Lacambre et Persac	Brussels-city	Persac	Brussels-city			Brussels	Belgium		
AC2135 (ind1101)	1842	Perfectionnement	thermal	melting furnace	Lacambre	Brussels-city	Persac	Brussels-city			Brussels	Belgium		
AC2148 (ind978)	1842	Invention	thermal/mechanical	new type of annealer	Houtard-Roullier	Charleroi-city					Charleroi	Belgium		
AC3652 (ind3930)	1846	Importation	other/unknown	improvements of glass production	sieurs Nicolson et Wadsworth							United Kingdom	R. W. Urling	Saint-Josse-ten-Noode
AC3888 (ind4285)	1847	Importation	other/unknown	improvements of glass production	sieur Bessemer							United Kingdom	R. W. Urling	Saint-Josse-ten-Noode
AC4281 (ind4935)	1848	Invention	thermal/mechanical	devices to transport glass into the annealing tunnel	Drapier	Brussels-city/Charleroi	Houtart	Brussels-city/Charleroi			Brussels/Charleroi	Belgium		
AC4423 (ind5203)	1848	Invention	thermal/mechanical	annealer	Schmidt et Comp	Montigny-sur-Sambre					Charleroi	Belgium		
ind5573	1848	Importation	other/unknown	improvements of glass production	sieur Bessemer							United Kingdom	W. H. Ritchie	Brussels-city
AC4623 (ind5842)	1849	Invention	thermal	devices to tranport pots in and out of melting furnace without cooling of the furnace	F. Schmidt	Montigny-sur-Sambre					Charleroi	Belgium		
AC5039 (ind6860)	1850	Invention	thermal/mechanical	annealer	C. Segard	Bergen					Boringage	Belgium		
AC5135 (ind5809)	1850	Perfectionnement	thermal/mechanical	improved annealer	M. J. Pasquet	Gilly					Charleroi	Belgium		

Patents 1855

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
ind799	Invention	thermal	melting furnace	J. -B. Lefebvre	Jumet					Charleroi	Belgium		
ind825	Invention	thermal	combined melting furnace for simultaneous production of clear and coloured glass	L. De Dorlodot	Couillet					Charleroi	Belgium		
ind830	Invention	thermal	layout of a melting furnace	D. Schmidt	Charleroi					Charleroi	Belgium		
ind907	Invention	thermal	cokes-fired melting furnace	L.-J. Brunfaut	Montigny-le-Tilleul					Charleroi	Belgium		
ind937	Invention	thermal/mechanical	annealer	D. Jonet	Couillet					Charleroi	Belgium		
ind974	Perfectionnement	thermal	melting furnace	L.-A. Quertinier	Charleroi-stad					Charleroi	Belgium		
ind984	Invention	thermal	melting furnace with improved fuel-burning	C. Lambert-fils	Lodelinsart					Charleroi	Belgium		
ind991	Invention	thermal	melting furnace with improved gas canals	J. Gérard	Charleroi-stad					Charleroi	Belgium		
ind992	Invention	thermal	melting furnace	J. Daubresse	Saint-Vaast (La Louvière)					Centre	Belgium		
ind1038	Perfectionnement	thermal	melting furnace with improved gas and air canals	L.-J. Brunfaut	Montigny-le-Tilleul					Charleroi	Belgium		
ind1054	Invention	thermal	use of lost warmth of a melting furnace for the heating on an annealer	C.-J. Lambert-fils	Lodelinsart					Charleroi	Belgium		
ind1055	Invention	thermal/mechanical	improved annealer	H. Houtart-Roullier	Charleroi-city					Charleroi	Belgium		
ind1434	Invention	thermal	melting furnace with ventilation for better burning	D. Jonet	Couillet					Charleroi	Belgium		
ind1539	Importation	thermal	combination of cokes-furnace with a glass-melting furnace	O.-J. Salmon							France	H. Biebuyck	Brussels-city
ind1536	Invention	mechanical	table for the cutting of glass	J. Soupart	Jumet					Charleroi	Belgium		
ind1548	Invention	thermal/mechanical	annealer	H. Bertiaux	Charleroi-city					Charleroi	Belgium		
ind1682	Invention	thermal	melting furnace	Lambert-fils	*not indicated*					Charleroi	Belgium		
ind1846	Invention	mechanical	table for the cutting of glass	E. Bourguignon	Dampremy					Charleroi	Belgium		
ind1907	Invention	thermal	melting of glass in two steps	G. Dulmer	Namen					Namen	Belgium		
ind1950	Perfectionnement	thermal/mechanical	annealer	H. Bertiaux	Charleroi-city					Charleroi	Belgium		
ind1960	Invention	mechanical	table for the cutting of glass	P.-J. Martaux	Lodelinsart					Charleroi	Belgium		
ind1933	Perfectionnement	thermal	melting of glass in two steps	G. Dulmer	Namur					Namur	Belgium		
ind2105	Importation	chemical	components	L.-J.-F. Marguerritte							France	A. Boitard	Brussels-city

Patents 1860

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
8676	Invention	thermal/mechanical	annealer	P.-J. Wery	Jumet					Charleroi	Belgium		
9029	Invention	thermal	melting pot with compartments	Vanderborght	Brussels-city	De Gand	Brussels-city			Brussels	Belgium		
9118	Importation	thermal	double melting furnace for continuous working	Gobbe frères		J.-J. Devillez (J.-J.)	*not indicated*				*unclear*	*not mentioned*	Brussels
9156	Perfectionnement	thermal	melting furnace	J. Gerard	Charleroi-city					Charleroi	Belgium		
9502	Importation	thermisch	double melting furnace for continuous working	A. Riols de Fonclare							*unclear*	*not mentioned*	Brussels
9755	Invention	thermal/mechanical	device to transport cylinders into annealer	J.-B. Fondu	Lodelinsart					Charleroi	Belgium		
9875	Perfectionnement	thermal/mechanical	improvement of a device to transport cylinders into annealer	J.-B. Fondu	Lodelinsart					Charleroi	Belgium		
9903	Invention	mechanical	device to transport pots	J. Piérard	Gilly					Charleroi	Belgium		

Patents 1865

Number	Patent category	Type of knowledhe	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Regin	Country	Belgian representative	Location representative
17304	Invention	chemical	treatment to avoid the irisation of glass	Renard, père et fils	Mons					Borinage	Belgium		
17734	Invention	chemical	treatment to avoid the corrosion of glass	W.-B. Richards							United States/France (patentee American, patent first registered in France)	*not mentioned*	Brussels-city
17761	Invention	thermal	furnace for the production of melting pots	C. Lambert-fils	Lodelinsart					Charleroi	Belgium		
17993	Invention	thermal	improved furnace	H. Boetius							unclear, presumaby one of German states (patentee was German)	*name unreadable*	Saint-Josse-ten-Noode
18085	Invention	mechanical	pneumatical apparatus for the blowing of cylinders	Ravelli-Candido	Brussels-city					Brussel	Belgium		
18339	Invention	thermal/mechanical	mechanical parts of an annealer	L. Baudoux	Chareroi-city					Charleroi	Belgium		
18453	Perfectionnement	thermal/mechanical	improvements of mechanical parts of an annealer	L. Baudoux	Chareroi-city					Charleroi	Belgium		
18650	Perfectionnement	mechanical	improvement of pneumatical apparatus for the blowing of cylionders	Ravelli-Candido	Brussels-city					Brussel	Belgium		
18805	Importation	thermal/mechanical	enclosed cart for an annealer	W. Dillinger							unclear	*not mentioned*	Brussels-city
18833	Perfectionnement	thermal/mechanical	improvements of mechanical parts of an annealer	L. Baudoux	Chareroi-city					Charleroi	Belgium		
18834	Invention	thermal/mechanical	annealer	L. Baudoux	Chareroi-city					Charleroi	Belgium		

Patents 1870

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
27015	Invention	thermal/mechanical	Bricks for annealers	A. Maiglet	Buvrinnes (Binche)					Centre	Belgium		
27088	Invention	mechanical	*manique*	A. Jacqmain	Lodelinsart					Charleroi	Belgium		
27183	Invention	thermal	improved Siemens furnace	G. Dümler	Elsene					Brussels	Belgium		
27326	Invention	mechanical	*bloc du souffleur*	R. Degaugue	Jemappes	H. Soupart	Jemappes			Borinage	Belgium		
27350	Invention	mechanical	device for the cutting of cylinders	H. Boetius	Schaerbeek					Brussels	unclear, presumaby one of German states (patentee was German)	*not mentioned*	
27376	Invention	thermal/mechanical	annealers	M. Evrard	Lodelinsart					Charleroi	Belgium		
27425	Invention	thermal	gas-firing of furnaces	L.-N. De Meckenhelm	Lodelinsart					Charleroi	Belgium		
27451	Invention	thermal	apparus for making of blocks for furnaces	L. Faux	Lodelinsart					Charleroi	Belgium		
27598	Perfectionnement	thermal	furnace	H. Boetius	Schaerbeek					Brussels	unclear, presumaby one of German states (patentee was German)	*not mentioned*	
27649	Invention	thermal/mechanical	improved annealer	Bennert et Bivort	Jumet					Charleroi	Belgium		
27651	Invention	thermal	improved melting furnace	Bennert et Bivort	Jumet					Charleroi	Belgium		
27775	Importation	thermal/mechanical	annealer	A.-R. Gugnon							unclear	*not mentioned*	Schaerbeek
27944	Invention	chemical	composition and treatment of components to improve quality	S. Manteau	Dampremy					Charleroi	Belgium		
28187	Invention	mechanical	*manique*	F. Schmidt	Charleroi-city	J. Herman	Charleroi-city			Charleroi	Belgium		

Patents 1875

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
36936	Invention	mechanical	*bloc de souffleur*	E.-F. Joseph	Lesve (Profondeville)					Namur	Belgium		
37132	Invention	mechanical	*bloc de souffleur*	A. Dailly	Charleroi-city					Charleroi	Belgium		
37164	Invention	mechanical	device for filling of pots	A. Dailly	Charleroi-city					Charleroi	Belgium		
37218	Perfectionnement	mechanical	*bloc de souffleur*	E.-F. Joseph	Lesve (Profondeville)					Namur	Belgium		
37264	Invention	mechanical	*bloc de souffleur*	P. Baufay	Gilly					Charleroi	Belgium		
37572	Invention	thermal	use of gas for the firing of a furnace	J. Devillez	Lodelinsart					Charleroi	Belgium		
37605	Invention	mechanical	*bloc de souffleur*	E. Parfait-Cornil	Jumet					Charleroi	Belgium		
37700	Invention	thermal/mechanical	new type of cart for annealers	J.-L. Henry	Jumet					Charleroi	Belgium		
37785	Invention	mechanical	*bloc de souffleur*	J.-J. Lembert	Roux	A. Lembert	Roux	J. Bauthier	Roux	Charleroi	Belgium		
38376	Invention	thermal	pot for melting furnaces	A. Mathy	Brussels-city					Brussels	Belgium		

N.B. In 1875 five patents for the tempered glass (objects and flat glass) were registered (37215, 37293, 37614, 37702, 38110). These were not included in calculations as they go beyond the main topic of this study, being the ordinary window glass in the first place

Patents 1880

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee	Location 3	Region	Country	Belgian representative	Location representative
50309bis	Importation	thermal	melting furnace	C.-W. Siemens							Germany	*not mentioned*	Brussels-city
50505bis	Invention	thermal/mechanical	system of carts for an annealer	C. Lambert	Lodelinsart					Charleroi	Belgium		
50622	Importation	thermal	gas furnace	U. Mantrant							*unclear*	*not mentioned*	Brussels-city
50626	Perfectionnement	thermal	improvement of glass melting process	G. Leuffgen	Brussels-city					Brussels	Belgium		
50799	Importation	thermal	gas furnace	Renard, père et fils, et Cie							*unclear*	*not mentioned*	Mons
51080	Invention	thermal	ventilation of furnaces	M.-L. Honnay	Fleurus					Charleroi	Belgium		
51106	Invention	thermal/mechanical	annealer	L. Bricoult	Lodelinsart					Charleroi	Belgium		
51136	Invention	thermal	melting furnace	E. Gobbe	Lodelinsart					Charleroi	Belgium		
51137	Invention	thermal	improved tank and pot furnace	E. Gobbe	Lodelinsart					Charleroi	Belgium		
51157	Perfectionnement	thermal	improved tank furnace	L. Baudoux	Charleroi-city					Charleroi	Belgium		
51304	Invention	thermal	melting furnace	D. Merny	Namur					Namur	Belgium		
51460	Invention	thermal	improved melting furnace	L. Stenger	La Louvière					Centre	Belgium		
51505	Importation	thermal	combined tank and pot furnace	Caton, père et fils							*unclear*	*not mentioned*	Charleroi
51740	Importation	thermal	tank furnace	H. Quennec							*unclear*	*not mentioned*	Ixelles
51776	Importation	chemical	composition of coloured glass	J. La Farge							USA/France (imported from France, original patent from the USA)	*not mentioned*	Liège
51930	Invention	thermal	improved tank furnace	C.-W. Siemens							Germany	*not mentioned*	Brussels-city
52090	Invention	mechanical	*bloc de souffleur*	F. Culot	Jumet					Charleroi	Belgium		
52325	Invention	mechanical	*bloc de souffleur*	E. Wery	Jumet	G. Schirman	Jumet			Charleroi	Belgium		
52360	Invention	mechanical	*bloc de souffleur*	V. Houze	Jumet					Charleroi	Belgium		
52563	Invention	thermal	improved tank furnace	M.-A. Oppermann	Brussels-city/Charleroi					Brussels/Charleroi	Belgium		
52615	Importation	thermal	melting furnace	J. Marchard							*unclear*	*not mentioned*	Saint-Josse-ten-Noode
52704	Importation	mechanical	system for spraying glass cylinders with water	J. Treuffet							*unclear*	*not mentioned*	Mons
52856	Invention	thermal	improved gas-fired pot furnace	M.-A. Oppermann	Brussels-city/Charleroi					Brussels/Charleroi	Belgium		
52916	Invention	thermal	melting furnace	F. Lurmann	Liège					Liège	Belgium		
52928	Importation	thermal	tank furnace	Société Générale de Métallurgie							*unclear*	not mentioned	Sant-Josse-ten-Noode
52930	Invention	thermal	tank furnace	Société Générale de Métallurgie	Saint-Josse-ten-Noode					Brussels	Belgium		
53065	Invention	other	warm polishing process of window glass	F. W. Konitzky	Brussels-city					Brussels	Belgium		
53164	Invention	mechanical	*bloc de souffleur*	G. Dineur	Lodelinsart	A. Dandoy	Lodelinsart	J.-J. Mal	Lodelinsart	Charleroi	Belgium		
53257	Invention	mechanical	*bloc de souffleur*	J. Vanderstock	Lodelinsart	R. Longfils	Lodelinsart		Lodelinsart	Charleroi	Belgium		
53259	Invention	thermal	vault of a melting furnace	E. Baudoux	Lodelinsart				Lodelinsart	Charleroi	Belgium		
53260	Invention	mechanical	ventilation of glass factory halls	E. Baudoux	Lodelinsart				Lodelinsart	Charleroi	Belgium		

Patents 1885

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
67400	Invention	thermal	improved gas-fired pot furnace	F. Schmidt-Devillez	Dampremy					Charleroi	Belgium		
67579	Invention	thermal/mechanical	improved annealer	F. Deulin	Jumet	R. Deulin	Jumet			Charleroi	Belgium		
67742	Invention	thermal/mechanical	equipment for the transport of pots in melting furnace	P.-J. Busez	Haine-Saint-Paul (La Louvière)	L.-V. Moriau	Haine-Saint-Paul (La Louvière)			Centre	Belgium		
67973	Invention	thermal	small vault for the annealing of cylinders	E. Masquelier	Lodelinsart					Charleroi	Belgium		
68119	Importation	thermal	recuperation for tank furnaces with gas producer	A. Charneau	Paris						France	*not mentioned*	Brussels-city
68164	Perfectionnement	other	composition of paste for the treatment of annealer's stones	P.-J. Castin	Lodelinsart					Charleroi	Belgium		
68184	Invention	thermal/mechanical	equipment for the treatment of gass in an annealer	F. Daugneaux	Jumet					Charleroi	Belgium		
68185	Invention	thermal/mechanical	equipment for the pre-heating of cylinders before annealing	J. Cosse	Montigny-sur-Sambre					Charleroi	Belgium		
68475	Importation	thermal	tank furnace	Guibert et fils et Bobet							*unclear*	*not mentioned*	Brussels-city
68608	Perfectionnement	thermal	improved tank furnace	L. Baudoux	Charleroi-city					Charleroi	Belgium		
68827	Perfectionnement	thermal	improved gas producer for pot furnaces	L. Baudoux	Charleroi-city					Charleroi	Belgium		
68934	Invention	mechanical	device for the cutting of glass cylinders	L. Wery	Jumet					Charleroi	Belgium		
69025	Invention	thermal	recuperator for furnaces	E. Fourcault	Lodelinsart	E. Jacques	Lodelinsart			Charleroi	Belgium		
69322	Importation	thermal	Boëtius-furnace	Société Appert frères							France	*not mentioned*	Brussels-city
69561	Invention	mechanical	table for the cutting of glass	M. Lebeau	Lodelinsart					Charleroi	Belgium		
70107	Invention	thermal	improved Siemens furnace	H.-J. Jacobsen	Brussels-city					Brussels	Belgium		
70283	Invention	mechanical	table for the cutting of glass	L. Lebeau	Lodelinsart					Charleroi	Belgium		
70818	Importation	thermal	tank furnace	R. Radot		L. Renard					*unclear*	*not mentioned*	Brussels-city
71006	Importation	thermal	vaults for melting furnaces	A. Charneau							*unclear*	*not mentioned*	Brussels-city
71094	Invention	mechanical	device for the cutting of glass	E. Biévez	Jumet					Charleroi	Belgium		
71132	Invention	thermal	melting furnace	A. Hahne	Brussels-city					Brussels	Belgium		
71169	Invention	thermal/mechanical	annealer	J. Paour	Brussels-city					Brussels	Belgium		
69954	Invention	mechanical	pneumatic blowing of glass cylinders	M.-A. Oppermann	Brussels-city/Charleroi					Brussels/Charleroi	Belgium		

Patents 1890

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
89078	Importation	thermal/mechanical	improved annealer	O. Lippert	Ixelles						*unclear*		
89588	Invention	chemical	composition opal glass	M.-J. Kempner	Brussels-city					Brussels	Belgium		
89622	Invention	thermal/mechanical	annealing	E. Biévez	Jumet	L. Biévez	Jumet			Charleroi	Belgium		
89911	Invention	thermal/mechanical	apparatus for the heating of glass cylinders (presumably before annealing)	Verreries de Jumet	Brussels-city/Charleroi					Brussels/Charleroi	Belgium		
89946	Invention	mechanical	*manique*	M.-A. Oppermann	Brussels-city/Charleroi					Brussels/Charleroi	Belgium		
90435	Invention	thermal	improved melting furnace	L. Baudoux	Brussels-city/Charleroi					Brussels/Charleroi	Belgium		
90447	Invention	thermal/mechanical	apparatus for the heating of glass cylinders (presumably before annealing)	F. Morel	Lodelinsart					Charleroi	Belgium		
90904	Invention	thermal	improved tank furnace	E. Gobbe	Lodelinsart					Charleroi	Belgium		
91120	Perfectionnement	thermal	improved tank furnace	L. Baudoux	Uccle/Charleroi					Brussels/Charleroi	Belgium		
91318	Perfectionnement	thermal/mechanical	improved annealer	L. Baudoux	Uccle/Charleroi					Brussels/Charleroi	Belgium		
91397	Invention	mechanical	production of flat glass wirth compressed air	H. Hilde	Brussels-city					Brussels	Belgium		
92098	Invention	thermal/mechanical	apparatus for the heating of glass cylinders (presumably before annealing)	L. Faux	Lodelinsart					Charleroi	Belgium		
93068	Invention	thermal	tank furnace	F. Wauthier	Gilly					Charleroi	Belgium		
93228	Invention	thermal	improved tank furnace	M. Colin	Courcelles					Charleroi	Belgium		

Patents 1895

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
113999	Invention	thermal/mechanical	Heating of glass cylinders before annealing in circular motion	Verreries de Jumet	Jumet					Charleroi	Belgium	Depasse	Jumet
114933	Perfectionnement	thermal/mechanical	Improved annealing plate for annealers	Chance Brothers et J.-E. Scott	West-Bromwich						United Kingdom	Kirkpatrick	Brussels-city
118232	Invention	mechanical	*bloc de souffleur*	L. Stenger	Lodelinsart	H. Scohy	Lodelinsart			Charleroi	Belgium		
119135	Invention	thermal/mechanical	apparatus for the heating of cylinders before annealing	J. Cosse	Lodelinsart					Charleroi	Belgium		

Patents 1900

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
147213	Invention	mechanical	glass-cutting machine	C. Dugon	Lyon						France	De Visscher et Graetz	Brussels-city
148083	Invention	thermal/mechanical	annealer	O. Masquelier	Jumet					Charleroi	Belgium		
149182	Perfectionnement	thermal	melting pot with compatments for continuous production	L.-M. Règle	Nesle-Normandeuse						France	Wiesmann	Brussels-city
149917	Invention	chemical	composition of coloured glass, calcium carbonate replaced by barium	H.-E. Knospel	Hillemühl (Mlýny)						Bohemia	Duvinage	Brussels-city
150031	Invention	mechanical/electric	cutting of glass with electrically-heated wire	L. Schmidt	Roux					Charleroi	Belgium		
149808	Invention	thermal	gas furnace with enclosed pots	F.-J. Swoboda	Kreibitz (Chřibská)						Bohemia	Duvinage	Brussels-city
150411	Invention	thermal/electric	melting of glass with electricity	J. Bertrand	Straatsburg						Germany	Duvinage	Brussels-city
150783	Invention	thermal/electric	electrical melting furnace	Gesellschaft zür Verwerthung der Patente für Glaserzeugung auf elektrischem Wege, Becker et C°	Cologne						Germany	Comptoir indus. et tech (anc. Maison Picard)	Brussels-city
151149	Invention	thermal/electric	electrical melting furnace	Gesellschaft zür Verwerthung der Patente für Glaserzeugung auf elektrischem Wege, Becker et C°	Cologne						Germany	Comptoir indus. et tech (anc. Maison Picard)	Brussels-city
151411	Invention	mechanical	glassblowing cane with provision against moisture	Oberlausitzer Glashüttenwerke, Otto Hirsch	Weiswasser						Germany	De Visscher et Graetz	Brussels-city
152956	Invention	thermal	furnace for re-melting of cullet	E. Martin	Laeken					Brussels	Belgium		
154001	Invention	thermal	gas producer for annealers	A. Decelle	Lodelinsart					Charleroi	Belgium		
153676	Invention	thermal/electric	electrical melting furnace	Gesellschaft zür Verwerthung der Patente für Glaserzeugung auf elektrischem Wege, Becker et C°	Cologne						Germany	Wunderlich	Brussels-city
153637	Invention	chemical	colouring glass yellow, red and brown with lignite and peat	N. Meurer	Cologne						Germany	Joerissen	Brussels-city

Patents 1905

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
182038	Invention	thermal/mechanical	annealer with hanging glass plates in order to prevent contact with surface	J. Craig	Parnassus	R.-E. Rowan	Parnassus				VSA	Hamal	Liège
182336	Invention	mechanical	attachment for the cutting of glass with a diamond	J. Degrez	Jumet-Hamendes					Charleroi	Belgium		
182342	Invention	thermal	melting furnace	E. Gobbe	Jumet					Charleroi	Belgium		
183693	Invention	thermal	recuperator for gas furnaces	E. Gobbe	Jumet					Charleroi	Belgium		
183804	Invention	mechanical	equipment for the drawing of flat glass	P.-T. Sievert	Dresden						Germany	De Visscher et Graetz	Brussels-city
184551	Invention	mechanical	machine for the blowing of glass cylinders	G. Schluder	Dresden						Germany	Duvinage	Brussels-city
185673	Invention	mechanical	equipment for the drawing of flat glass	I.-W. Colburn	Franklin						United States	Raclot	Brussels-city
185618	Perfectionnement	mechanical	installation for the drawing of flat glass	E. Fourcault	Lodelinsart						Belgium		
186264	Invention	mechanical	equipment for the drawing of flat glass	E. Rowart	Auvelais					Namur	Belgium	Biebuyck	Brussels-city

Patents 1910

Number	Patent category	Type of knowledge	Subject	Patentee 1	Location 1	Patentee 2	Location 2	Patentee 3	Location 3	Region	Country	Belgian representative	Location representative
222745	Importation	thermal/mechanical	annealer	Société anonyme des Verreries et Manufactures de Glaces d'Aniche	Aniche						France	Noël	Brussels-city
224174	Invention	mechanisch	*manique*	J.-A. Dehut	Lodelinsart	E. Delacuvellerie	Charleroi-city			Charleroi	Belgium		
223902	Invention	mechanical	drawing of flat glass	O. Deprez	Brussels-city					Brussels	Belgium	Collinet	Brussels-city
223414	Importation	mechanical	drawing of flat glass	J. Player	River Forest						United States	Raclot et Cie	Brussels-city
225588	Invention	thermal	melting furnace	G.-H. Baillie	Londen						United Kingdom	Raclot	Brussels-city
225636	Invention	thermal/mechanical	annealer	G.-H. Baillie	Londen						United Kingdom	Raclot	Brussels-city
225308	Invention	mechanical	device for the 'opening' of glass cylinders	Empire Machine Company	Pittsburg						United States	Comptoir indus. et tech	Brussels-city
225587	Invention	mechanical	mechanical blowing of cylinders	Empire Machine Company	Pittsburg						United States	Raclot	Brussels-city
225720	Invention	mechanical	cutting of glass with heated wire	Empire Machine Company	Pittsburg						VSA	Raclot	Brussels-city
225637	Invention	thermal/mechanical	annealer	V.-H. Gregory	Chiswick						United States	Raclot	Brussels-city
225179	Perfectionnement	thermal	melting furnace	C. Royer	Lyon						France	Raclot	Brussels-city
226310	Invention	thermal/mechanical	annealing tunnel	E. Gobbe	Jumet					Charleroi	Belgium		
226384	Perfectionnement	thermal/electric	electric melting furnace	Siemens & Halske	Berlin						Germany	*not mentioned*	Brussels-city
227338	Invention	thermal	furnace for glass-drawing	Empire Machine Company	Pittsburg						United States	Raclot	Brussels-city
227970	Importation	thermal	melting furnace	Empire Machine Company	Pittsburg						United States	*not mentioned*	Brussels-city
228184	Invention	chemical	elimination of sulplate vapours by adjusted composition	J. Gathy	Mons					Borinage	Belgium		
228185	Perfectionnement	chemical	elimination of sulplate vapours by adjusted composition	J. Gathy	Mons					Borinage	Belgium		
229009	Invention	thermal	furnace with compartments for the production of coloured glass	O. Debroux	Waudrez (Binche)					Centre	Belgium		
230050	Importation	thermal/mechanical	equipment for annealing	The Window Glass Machine Company	Pittsburg						United States	Comptoir indus. et tech	Brussels-city