What location policy can bring to sustainable commuting: an empirical study in Brussels and Flanders, Belgium

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What location policy can bring to sustainable commuting:
an empirical study in Brussels and Flanders, Belgium.

ABSTRACT

Policies on spatial planning and on mobility often take it for granted that a location policy that favours situating human activities near junctions of public transport results in a frequent use of sustainable modes of transport. But in the daily practice of mobility planning we come across more and more critical statements. As the Flemish Ministry of Mobility and Public Works considers investing resources in an improved location policy, they asked for evidence on the possible results of location policy on sustainable commuting in a Flemish context, including Brussels. Quite exceptionally, we dispose of the individual census data from nearly all 1,2 million Flemish commuters. These detailed data allow a precise description of the commuter characteristics of different locations and allow constructing a robust geographical pattern. We focus the analysis on four kinds of locations: railway stations, public transport junctions, urban areas and areas with a high economic density. An exploratory data analysis suggests that people working and/or living in these areas travel less distance, especially by car, and make more use of public transport and slow modes. A cluster analysis shows that there are spatial differences, resulting in clear geographical patterns, which suggest that policies should be spatially differentiated. As a result, we support the idea of using location policy to reach more sustainable commuting. From a methodological point of view, we conclude that census data are irreplaceable to meet the requirements of spatial representativity needed to construct detailed geographical patterns of commuting.

KEY WORDS: mobility policy, location policy, spatial planning, commuting, census, Belgium

1. INTRODUCTION

In the Belgian practice of mobility management, we often hear, as we do elsewhere, that a good spatial planning is needed to locate housing and economic activities in such a way that it results in more sustainable mobility. More sustainable mobility implies less travelled distance, less car use and more use of public transport. Nowadays, Belgium features quite a lot of strategic urban projects with the purpose of locating new offices, retail and housing, especially around railway stations. Of course, the Belgian passenger railway company promotes this strategy, as they are the main owners of real estate and grounds around the stations. Through these projects, they can gain a substantial amount of money that can be invested in, for instance, costly new high-speed train infrastructures. In several cases, these large projects incite some interest groups to resist these real estate projects for quick profit. But generally, everyone agrees on the fact that the location of new activities around the railway stations only has advantages for the successful implementation of urban mobility. In other words: there is a common belief that location policy contributes to sustainable mobility. During the last decade of the previous century, the Netherlands, (being) Belgium's neighbour, already created an explicit location policy. The so-called A-B-C policy was an important policy measure in the nineties, but eventually the strategy was abandoned, as it did not seem to work. This experience curbed the enthusiasm for location policy somewhat in Belgium. But a closer look at the failure in the Netherlands learns that location policy as a whole did not fail, but that the willingness of firms to participate (invest) faltered because they refused to accept the very tight planning regulations near railway stations, especially the ban on building parking lots (Verroen et al, 2000).

This paper explores the effects of location policy on the development of sustainable mobility in Flanders (Belgium). On the one hand, the Mobility Plan for Flanders (Ministerie van de Vlaamse Gemeenschap, 2001) considers location policy as a condition for sustainable transport. The reduction in the amount of trips, the reduction in travel distances as well as the improvement of the spatial structure to stimulate alternatives for road transport are intended effects. On the other hand, spatial planning as defined in the Spatial Plan for Flanders (Ministerie van de Vlaamse Gemeenschap, 1997) states that a more compact land use for housing and economic activities will lead to more sustainable mobility.

Location policy may influence transport, but transport policy may also influence land use. This research has to take into consideration the complex interrelation of both policies. Moreover, a large number of other policy areas also influence the revealed characteristics of land use and transport, e.g. housing, environmental and economic policy. Wegener (2004) describes the 'land use transport feedback cycle'. The distribution of land use over the area, allowed by location policy, determines where human activities take place. To span the distance between activities, spatial interaction requires trips within the transport system. Transport policy provides a transport system with more or fewer opportunities for spatial interaction, which can be quantified by a measure of accessibility. The spatial pattern of accessibility is an important factor in taking location decisions. As a consequence, it can result in land use changes .

Figure 1: Relation between land use and transport

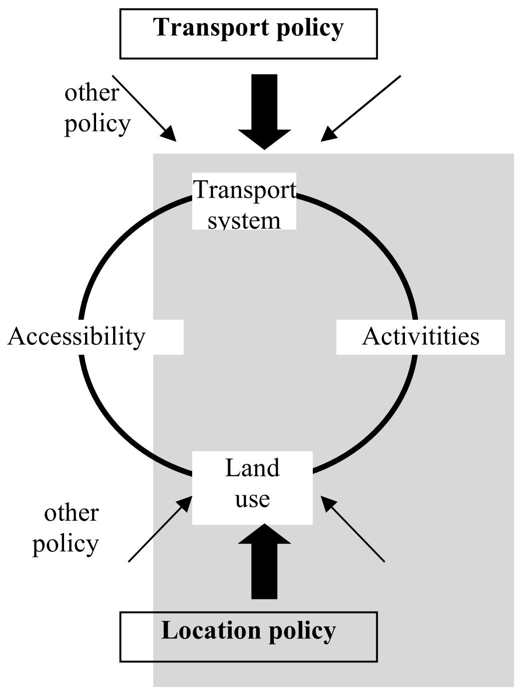


Figure 1, inspired by the Wegener’s 'land use transport feedback cycle' , shows the definition of our problem. The effects of location policy on transport as well as the effects of transport policy on land use are represented. The main goal of this paper is to quantify the effect of location policy on sustainable mobility (indicated with grey background on figure 1). Thus, this paper excludes the research field on the interaction between transport systems and land use through accessibility, which was recently extensively analysed for the Belgian context (Vandenbulcke *et al.*, 2009). We will evaluate different location strategies and study their possible effects on commuters’ mobility characteristics .

To begin with, we consider some reflections on the complex interrelations between location policy and mobility, based on an overview of the relevant literature (section 2). The empirical research focuses on commuter traffic in Flanders. The data stem from the 2001census and the methodology is explained in section 3. The empirical analysis is divided into two main parts: an analysis of market shares of commuting characteristics of selected locations (section 4) and a cluster analysis that provides a spatial synthesis of locations based on commuting characteristics (section 5). The market analysis first focuses on areas with different levels of accessibility by train (section 4.1) or by bus, tram and underground (section 4.2), being the result of mobility policies. Secondly, we focus on areas delineated by the spatial policy: i.e. priority areas for urbanisation (section 4.3) and for economic development (section 4.4). Do people living or working in these selected areas show different commuter characteristics than people living and working outside them? What level of sustainable mobility reaches the selected locations? In the conclusion we combine the answers to these questions with some suggestions for further research.

2. LITERATURE ON THE INTERRELATION OF LOCATION POLICY AND MOBILITY

The literature already reveals answers regarding the effects of location policy. An overview of the abundant amount of research in this field in the last 50 years, results in the identification of three stages. The conclusions on the interrelations between location policy and transport policy vary considerably between these stages. First, from the 1960s onwards, there was great trust in the positive effects of location policy on mobility. This was predominantly inspired by the classic economic urban models (i.e. economic urban models in the tradition of Alonso and Muth). These models have a clear link with welfare economics and utility maximization. They state that the spatial equilibrium between (central) job location and residential location is driven by income restrictions that limit commuting and residential costs (Fujita, 1989). During this period, little empirical evidence was provided, mainly due to a lack of detailed data and computing power. Next, from the 1980s onwards, a wide range of models, but mainly the four-step model, was developed in order to try to quantify the complex relation between location policy and mobility, and to overcome the 'beliefs' of the previous period by means of empirical evidence (Hensher *et al.*, 2000; McNally, 2000a). In this approach spatial gravity models are extensively elaborated. The empirical research resulted in doubt concerning the effect of location policy on mobility (XXX, 2001). Criticism mainly concerned the oversimplification of human behaviour and decision-making (Dieleman *et al.*, 1999). Subsequently, from the 1990s, in the 'activity-based models' (Ben-Akiva *et al.*, 1985; Timmermans *et al.*, 1990), attention was focused on the impact of lifestyle and variables, such as individual socio-economic characteristics and preferences for modes (Badoe *et al.*, 2000; Bagley *et al.*, 2002; McNally, 2000b; Mokhtarian *et al.*, 2001; Lyons and Chatterjee, 2008).

Increasingly more complex model building is going on (Bhat *et al.*, 2002), but the results of these new methods applied to commuting data, again reveal the importance of income level, housing preferences and commuting costs (mainly depending on mode choice and accessibility) (van Ommeren *et al.*, 1999; Van Wee, 2002; Ma *et al.*, 2006). This is due to the fact that commuting is part of the 'skeleton schedule' that consists of routine activities with almost no flexibility in place, time and mode (Roorda et al., 2007). And these clear-cut explanatory 'spatial' (housing environment – accessibility) and 'economic' (income level – commuting cost) variables bring us straight back to the explanatory variables given by the classic spatial economic urban models of the 1960s and their belief in location policy.

From the literature overview, we conclude that, during the last decade, research on location policy and commuting turned into very detailed data, like those derived from movement journals, that were modeled with innovative and sophisticated techniques, and resulted mainly in a synthesis of commuting characteristics by social, economic and psychological characteristics of the commuters. The geographical patterns or spatial synthesis of commuting in detailed maps somewhat disappeared. The present paper brings back an explicit spatial approach by using detailed census data for describing the relationship between location and commuting characteristics on the one hand and making a spatial synthesis through geographical, detailed maps. As van Wee (2002, 269) states in his list of challenges for research on land use and transport: "maps may prove to be very helpful in communicating the results".

3. HOW TO MEASURE THE IMPACT OF LOCATION POLICY: METHOD AND DATA

The central question is whether location policy can have an impact on transportation characteristics of commuters. Ideally, one would compare the commuting characteristics in one neighbourhood at two different moments in time: before and after the implementation of the location policy. But as there are up until now no explicit large-scale applications of location policy in Flanders, the impact of location policy is analysed with the following construction: the characteristics of commuters of neighbourhoods with specific location characteristics (e.g. railway station areas) are compared with the commuting characteristics of neighbourhoods that lack these location qualities. The Spatial Plan of Flanders defines different methods of location policy. First, the optimisation of the transport infrastructure is put forward, whereby transport-generating activities should be located near public transport junctions. This method is evaluated in the empirical analysis by determining the results of commuting behaviour of locations near railway stations (section 4.1) and bus, tram or underground stops (section 4.2). A second method entails the promotion of urban regions for housing and the selection of special gateways for economic activities, which, consequently, protects the countryside from further urbanisation. Therefore, in section 4.3, the neighbourhoods assigned by the Spatial Plan of Flanders as ‘urban development areas’ are compared to areas outside this delineation, while in section 4.4 regions with different levels of economic density are compared.

The data used in this contribution result from the processing of the 2001 census. The individual census data from nearly all 1,2 million Flemish commuters are available. All working people are included, also people living and working in the same local authority. This implies a large definition of commuting, all home-to-work trips are included. In our analysis, we aggregate these data to the level of neighbourhoods, which are the statistical sectors delineated by the Belgian Institute for Statistics and generally used for the benefit of detailed geographical analysis. Flanders is the Dutch-speaking, northern part of Belgium. As a considerable amount of Flemish commuters travel by train to their workplace in the central Brussels region, this region is included in the analysis of railway station locations near the workplace. The study includes for Flanders 9,182 statistical sectors of Flanders covering 13,522km^3, thus having a mean surface of 147km^2. For the Brussels region the numbers are respectively 724, 161km^2 and 0.22km^2. The information the census provides related to commuting entails: the neighbourhood of the workplace and the place of departure, the distance and frequency of the movements, the means of transportation generally used for commuting, the times of departure and arrival for the outward journey and the return journey. This list is complemented with the number of cars that the household has at its disposal. Finally, data on the median income level of the Flemish residential neighbourhoods are added in the spatial synthesis as a controlling variable.

The following variables are constructed by the neighbourhood: transport variables (main commuting mode: car, bike, on foot, train, bus, tram or underground, the relative share of households with more than two cars in the neighbourhood, the average commuting distance and average travel time) and location variables (share of commuters working in the CBD, share of commuters working and residing in the same statistical sector ('in = ss'), accessibility by public transport, urbanization level and level of economic density).

This detailed and complete database allows calculating market shares of different transportation modes. Absolute numbers of nearly the entire population are available, which provides the unique advantage of not being dependent on estimations produced by econometrics. When counting market shares, two different spatial approaches are always included. On the one hand, the results calculated by the location characteristics of the place of departure (mostly domicile) are presented, as well as, on the other hand, those of the workplace. The market shares of different modes and commuter characteristics by location typologies are presented in frequency tables in chapter 4. A cluster analysis, presented in chapter 5, provides a spatial synthesis of commuting in Flanders. Maps indicate the spatial inequalities in terms of commuter characteristics.

4. MARKET ANALYSIS: WHAT ARE THE COMMUTER CHARACTERISTICS OF SELECTED LOCATIONS?

Frequency tables are presented for various location types of public transport, urbanization and economic density. For each of these location types, all the neighbourhoods of Flanders are assigned to the subdivisions in sections 4.1 to 4.4, detailed information is provided on the definition of the different levels within the location types and the allocation of the neighbourhoods to these levels.

The market analysis focuses, firstly, on areas with different levels of accessibility by train (section 4.1) or by bus, tram and underground (section 4.2), being the result of mobility policies. Secondly, the focus is on areas delineated by the spatial policy: priority areas for urbanisation (section 4.3) and for economic development (section 4.4).

4.1 Railway station areas and their commuting characteristics

Levinson (2008) finds strong historical evidence on the co-development of land use and rail in London. In this paragraph, we analyse for Flanders and Brussels the use of rail, and more general the market share of different transport modes, for commuting in the vicinity of railway stations, not by comparing different situations in time but in space. Every neighbourhood with more than half of its surface within a distance of 3 kilometres to a train station is defined as a railway station area. Four different railway station areas were described according to the number of train stops per day. First, the neighbourhoods near a railway station with more than 300 stops on a weekday were grouped together. These railway stations are found mainly in the central metropolitan areas of Brussels, Antwerp and Ghent. The three main stations in Brussels even have more than 1,000 stops a day. On the second level are the neighbourhoods around railway stations with less than 300 but more than 150 stops a day. The areas close to a railway station with less than 150 but more than 75 daily stops constitute the third level. The fourth level consists of neighbourhoods around railway stations with no more than 75 stops a day. Areas with no railway station within 3 kilometres are the lowest level. We are aware of the fact that this is a rather simple way of making accessibility towards rail services operational. Further research could invest in methods as expressed by Ghebreegziabiher et al. (2006), but these are quite time-consuming due to the extensive data gathering. It seemed preferable to invest in testing four different location types, rather than limiting ourselves to railway station locations.

Table 1: Commuting characteristics per type of railway station area

PLEASE INSERT

The last column in table 1, which represents the amount of commuters belonging to a (certain) location type, shows that most commuters (40%) live in neighbourhoods classified as ‘non railway station areas’ constituting, consequently, a market share for rail travel of only 3%, while car use goes up to 79%. Also the use of other public transport and slow modes is very low, whereas the need to have two cars is very prominent. The market share for rail travel doubles to 6% in areas with a small increase in rail services (less than 75 stops a day). This small increase in rail services decreases the share of car use to 73%. At the other end, 22% of the commuters still have rail services ranging from good to very good in their neighbourhood, which results in trains being used by 8 to 10% of the commuters. In the areas with very good rail services, other means of public transport are also frequently used together with slow modes; this decreases the market share of car use to 53% (on average for Flanders: 71%).

When we consider the workplace, a different picture arises. In this case, only the area with a very high train supply attracts train commuting (20% market share). As soon as the supply lowers to maximum 300 stops per day, the train is not used more than on average. In Flanders and Brussels, 29% of the commuters work in a neighbourhood with a railway station that has a very good service level (more than 300 stops a day). These commuters travel relatively long distances (40 minutes on average) to their job, almost always located in the CBD (77%); here, car use falls back to 55% together with car ownership.

We can conclude that people living nearby a railway station, and especially commuters who have a job nearby the main railway stations, have more sustainable commuting characteristics. Obviously, high-quality site and employment conditions (e.g. high public transport accessibility) have a natural advantage in reducing vehicle trips (Hwang and Giuliano, 1990; Hanssen, 1995; Thorpe et al., 2000; Hess, 2006). Areas around railway stations often share several characteristics: for instance, the employer is located in an area of high employment density, employee parking is restricted, public transport service is frequent and widespread, and a significant number of employees commute relatively long distances. Those conditions offer employees more alternatives to driving alone and make it easier to use those alternatives.

4.2 Bus-tram-underground areas and their commuting characteristics

Railway stations will always imply huge investments, not only financially even more important is the large consumption of land that is needed for the location of new railway stations, especially in densely populated and urbanized regions like Flanders. As part of a mobility policy, new bus, tram and underground infrastructures are easier to build. The supply of bus, tram and underground stops is more spread out than that of rail stops, more neighbourhoods have these public transportation stops nearby and these stops are far less points of high job density. We distinguish four different levels of waiting time for a bus, tram or underground on a Tuesday morning between 6 and 9 am: wait less than 15 minutes, wait between 15 and 30 minutes, wait between 30 and 60 minutes, wait more than one hour. Some neighbourhoods have no bus, tram or underground stop at all. For the calculation of the waiting time, all stops where a bus, tram or metro stops during the morning rush hour were selected and then it was calculated how many times were stopped in that period, after which it was divided by three to know the number of stops per hour. . An average waiting time can then be derived from this. If there are several stops in a neighborhood, the stop with the shortest waiting time was chosen.

<u>Table 2</u>: Commuting characteristics per type of bus-tram-underground area

PLEASE INSERT

The longer the waiting time for a bus, tram or underground at the place of residence, the higher the car use. The only substantial amount of public transport users can be found in neighbourhoods with a waiting time of maximum 15 minutes. One third of the Flemish commuters live in a neighbourhood with a waiting time of less than 15 minutes for a bus, tram or metro between 6 and 9am on any given Tuesday. More than half of them have a job in a CBD. They use this kind of public transport twice as much as on average in Flanders. Together with a high market share for slow modes, this causes a relatively low share of car use, and the need for two cars is significantly lower in these areas. When the waiting time for a bus, tram or underground near one’s home is more than 15 minutes, we see no additional positive effects on sustainable commuting behaviour: car use is relatively high. As far as the workplace is concerned, again we see that commuters working close to public transport stops with the highest frequencies of services (less than 15 minutes waiting time) use the bus, tram or underground twice as much as on average. It can be concluded that only with a very good and nearby supply of busses, trams or undergrounds, commuters use public transport.

4.3 Urbanisation and commuting characteristics

As part of the implementation of the Spatial Plan for Flanders, urban areas were selected and delineated. The plan states that new urban functions must be located within the borders of these urban areas as much as possible. The aim to reach a higher level of sustainable mobility is one of the most important reasons for this policy. This is entirely in line with the findings of Naess (2005), whose study shows that residential location affects behaviour, also when taking into consideration socioeconomic and attitudinal differences among inhabitants. Due to the location of the residence in relation to concentrations of facilities, living in a dense area close to downtown Copenhagen contributes to less travel, a lower share of car driving and more trips by bike or on foot. In the present research we check this conclusion for commuting from different levels of urban hierarchy in Flanders. A hierarchy of urban areas is introduced: at the top we find the metropolitan areas of Antwerp and Ghent, followed respectively by the regional urban areas and the small urban areas, the Flemish urban border around Brussels is a separate group. Outside these areas urbanization is being discouraged.

Table 3: Commuting characteristics per urban type

PLEASE INSERT

Most Flemish commuters live outside the delineated urban areas (57%). The least sustainable commuting behaviour is found among this large group of commuters which, evidently, determines the average. When it comes to commuting, the metropolitan areas are the most sustainable. Bus, tram and/or metro are used fairly frequently, but there is also a relatively good use of slow modes to the workplace. Going to work by bike or on foot are popular means of transport in regional and small urban areas. The relatively short distances and reduced levels of traffic, thus resulting in a safer environment, almost certainly play a role in this (Vandenbulcke et al., 2009). In all types of urban areas the ownership and use of a car for commuting purposes is relatively low. Commuters travelling from the Flemish Border around Brussels use the bus, tram or underground quite frequently, since the distance to work is relatively short (13 km compared to 17 km on average for Flanders).

34% of the commuters work outside the delineated urban areas. Their commuting behaviour determines the average. The most sustainable commuting routes lead to the metropolitan areas of Antwerp and Ghent. The least sustainable commuting route, characterised by a relatively greater car use as well as a longer travel distance and longer travel times, is to the Flemish-speaking municipalities surrounding Brussels.

This division into different urbanisation groups is very useful. Depending on the type of urbanisation area that we are dealing with, we can observe a noticeably different kind of commuting behaviour. What is particularly remarkable is the exceptional attraction that the Flemish Border around Brussels seems to exude. Commuters working in this region often have to travel a long distance and are apparently willing to spend a significant amount of time in their car to do so. Further research is needed to determine whether these are highly skilled professionals who have specialised jobs in the peripheral office districts, and whether part of their income comprises a company car, which is then, naturally, used to its full advantage.

4.4 Economic density and commuting characteristics

In Flanders, for decennia we had a spread of economic activities due to spatial-economic politics aimed at giving everybody a job in his/herown region/commune. The recent Spatial Plan of Flanders seeks to concentrate jobs in zones and corridors with accessibility profiles that attribute to sustainable mobility. In this paragraph we zoom on areas that have already a higher density of jobs, where we check if commuter characteristics are different. We expect a more sustainable profile of commuters in employment-rich regions, as reported by several case studies (van Wee *et al.*, 1996; Schwanen *et al.*, 2004; Shuttleworth *et al.*, 2005). For the sake of spatial-economic policy, Flanders is divided into four areas with a different economic density. These areas are delimited with parameters concerning employment, value-added and turnover (Cabus *et al.*, 2004). Economic core area 1 has the strongest economic density: it contains more than half of Flanders' economic activity. Economic core area 2 is three times less important. Areas of more than local importance host 10% of the economy, whereas the other areas are for the main part rural, suburban and coastal municipalities. These economic density areas are defined on the scale of municipalities, not on the more detailed level of neighbourhoods. This results in a somewhat less precise delineation that includes some neighbourhoods that do not cover the mentioned characteristics of economic density.

Table 4: Commuting characteristics per area of economic density

PLEASE INSERT

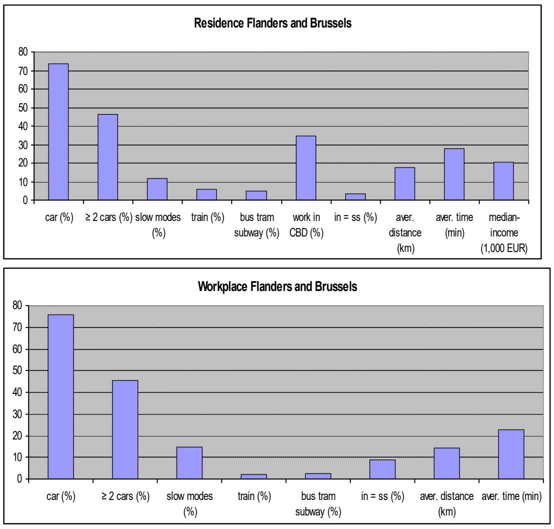
Only commuters residing in economic core area 1 (42% of the Flemish commuters) show a little more sustainable travel behaviour: less car use and ownership, more commuting by bus, tram and underground and slow modes, and the distance to their place of work is relatively shorter. Commuters living in an area of lower economic density (22%) travel a longer distance to their workplace, and they commute far more by car and less by slow modes as well as by bus, tram or underground.

Commuters working in economic core area 1 (nearly two thirds of the Flemish commuters) use public transport more often. The travel time for these commuters is longer: they are recruited from a wider area, as this dense economic area attracts more workers and offers specialized employment. Areas with lower density attract more workers living in the same neighbourhood or on shorter distances.

5 SPATIAL PATTERNS OF LOCATION AND COMMUTING CHARACTERISTICS IN FLANDERS

In order to get a spatial synthesis, the Flemish and Brussels neighbourhoods are grouped through a cluster analysis using the commuting characteristics. The median income of the place of residence is also included as a controlling variable. We clustered the 9906 neighbourhoods using Ward's ascending hierarchical method (Ward, 1963). The results help us to understand the geography of commuter characteristics and suggest clues for a location policy. Figure 2 represents the average of the commuting characteristics of neighbourhoods in Flanders and Brussels, for the place of residence and the workplace respectively. In the next sections, the deviation of commuting characteristics will be set out against these averages for each cluster.

Figure 2: Average of the commuting characteristics of neighbourhoods in Flanders and Brussels (place of residence and workplace)

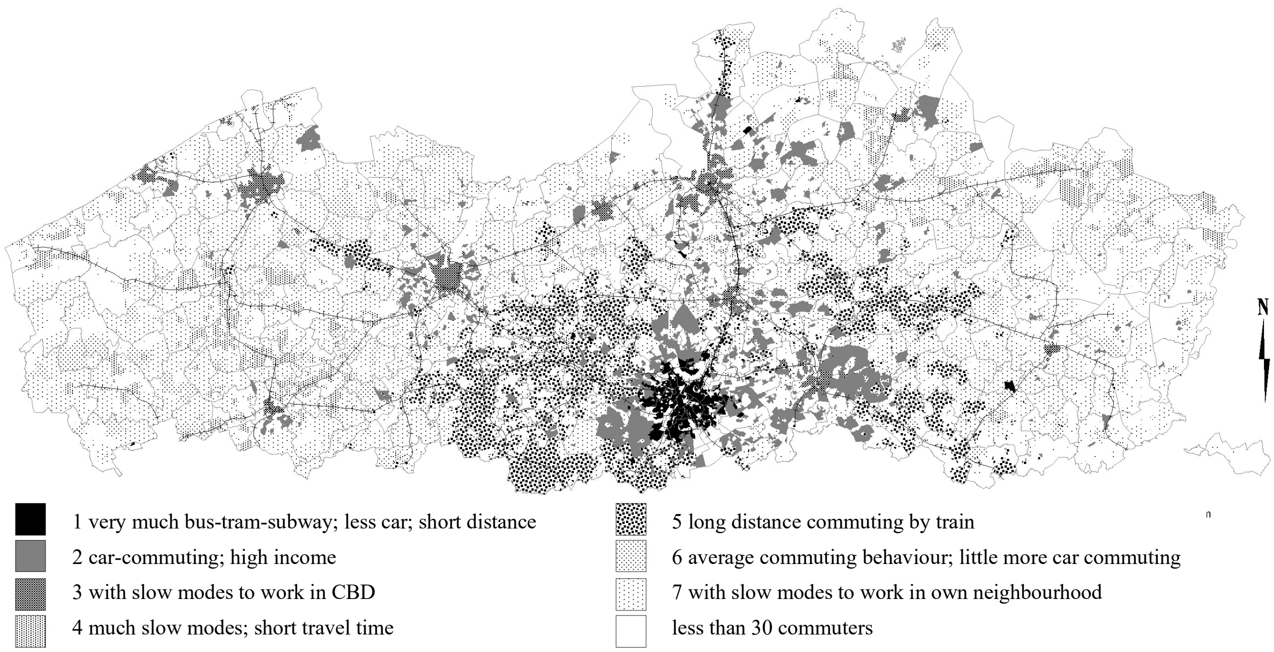


5.1 Cluster analysis per place of residence

A first cluster analysis deals with the commuters having Flanders or Brussels as their place of residence. Seven different clusters of neighbourhoods are distinguished. Appendix 1 represents the calculated z-scores for each commuting variable in the different clusters.

Cluster 1 shows commuters who use a bus, tram or underground more than averagely. Their distance to work is short and the median income is rather low. Commuters in *cluster 2* have a high income, and therefore possess more cars and commute more by car. 14% of the commuters belong to *cluster 3*, they use more slow modes and go to work in the Central Business District. *Cluster 4* also contains slow mode commuters, but their travel time is very short and they do not work in the CBD as much as the average commuter. Commuters from *cluster 5* are more than average train users who travel a long distance and have a long travel time to work. *Cluster 6* displays a rather average commuting behaviour with slightly more car use. *Cluster 7* contains neighbourhoods with relatively many commuters who go to work in local labour markets by bike or on foot.

Figure 3: Map of clusters based on characteristics of commuters residing in Flanders or Brussels



Cartography: University of Antwerp – Department of Transport and Regional Economics

Source: NIS SEE 2001 (census)

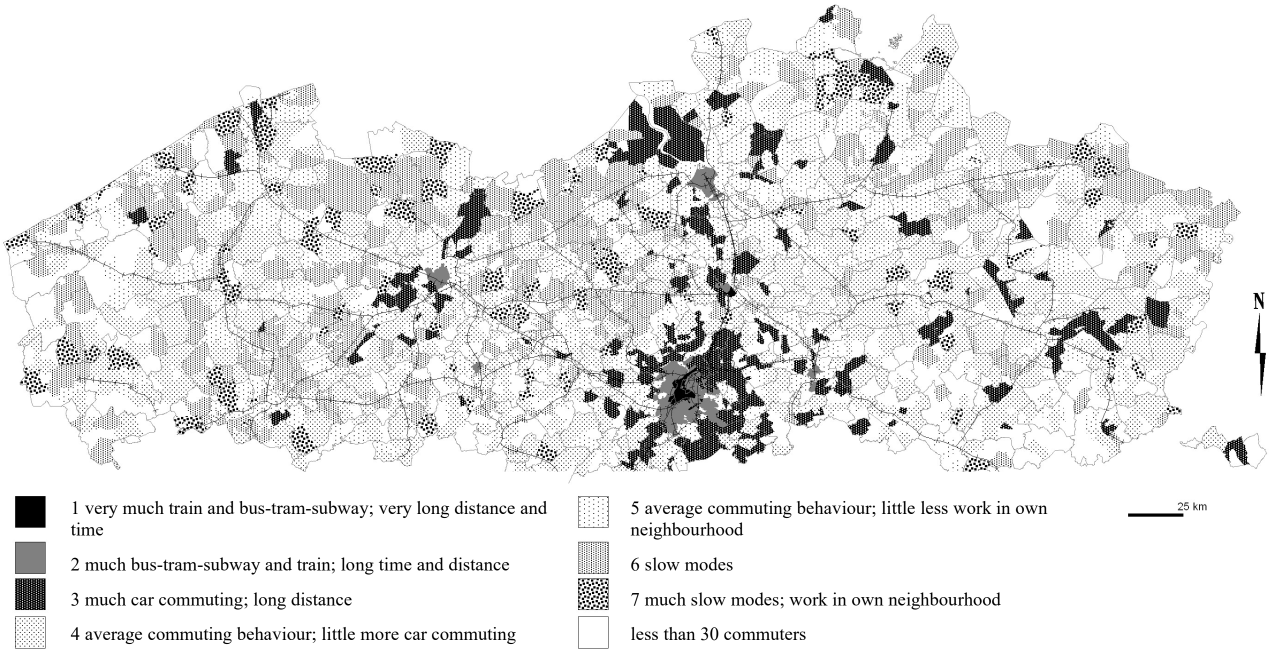
The distinguished clusters are mapped out in figure 3. Cluster 1is merely found in and around Brussels. The supply of public transport is very good and these commuters have only a short distance to travel to work. Around the big cities, and particularly around Brussels, there are many neighbourhoods with a relatively large number of car commuters who have a high income (cluster 2). Commuters in the centres of the Flemish cities (cluster 3) use more slow modes. Living in the close vicinity of their work in rather low-income neighbourhoods may play a role. Other slow mode commuters who do not work in the CBD, but have a rather short distance to travel to work can be found scattered in rural areas (cluster 4). Cluster 5 are the areas with relatively many train commuters, you can find them west and southwest of Brussels, and along railroad lines at a distance of 20 to 40 kilometres from Flemish cities. Cluster 6 dominates the map and represents statistical sectors with a lot of car commuters. The last cluster is found in peripheral areas with many commuters working in their own neighbourhood (cluster 7), they commute with slow modes more than on average.

5.2 Cluster analysis per workplace

This second cluster analysis groups the neighbourhoods of Flanders and Brussels together with the commuting characteristics that were calculated on the basis of the data of people having their work address in the quarter. For the workplace only eight variables were considered. The variables ‘work in CBD’ and ‘median income of the neighbourhood’ were removed, as they are not useful for this analysis. Again seven clusters arise (appendix 2).

C*luster 1* makes up 10% of the commuters who work in Flanders or Brussels. They are characterized by a more than average use of train and bus, tram or underground over a long distance and with a relatively long travel time. The car is used far less than on average. *Cluster 2* also shows sustainable commuting behaviour, but with more bus, tram and underground users than train users. Their distance and travel time to work are relatively long as well. Commuters to neighbourhoods in *cluster 3* also have a long travel distance to work, but they use their car more than on average. *Cluster 4* shows an average commuting behaviour with a slightly higher car use. 35% of the commuters are found in *cluster 5*, they too display average commuting behaviour, but they work in their own neighbourhood to a lesser extent than the average commuter. *Cluster 6* is characterized by the use of slow modes and covers a short distance. *Cluster 7* contains commuters working in their own neighbourhood who commute by bike or on foot.

Figure 4: Map of clusters based on characteristics of commuters with a workplace in Flanders or Brussels



Cartography: University of Antwerp – Department of Transport and Regional Economics

Source: NIS SEE 2001 (census)

Figure 4 maps out the seven clusters. Cluster 1 depicting train as well as bus, tram and underground users is found in the centre of Brussels and also in the centre of Mechelen. Cluster 2 areas with relatively much bus, tram and underground commuting can be found around the centre of Brussels and in the centre of certain Flemish cities. Long distance commuting by car (cluster 3) goes to the periphery of big cities such as Antwerp and Brussels. Car commuting at short distance (cluster 4) is more widely spread, at larger distances of the cities. Cluster 5 represents average commuting behaviour and covers mainly the Flemish suburban areas. Commuters travelling to their job by slow modes can be found in rural regions (cluster 6), while neighbourhoods with workers using more pronounced slow modes are found in traditional villages in rural regions (cluster 7).

6. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Due to the extensively available census data, which allowed constructing variables by neighbourhood out of data on individuals, we get a geographically complete image of commuting in Flanders and Brussels. Since no complex methodologies were needed to overcome data problems, we have managed to obtain very clear results. Needless to say, it is extremely regrettable that this was the very last chance to carry out such a task in Belgium, as no new census will be held in the future. This paper tried to take full advantage of this last opportunity.

The empirical study evaluates mobility strategies that were put forward in the Spatial Plan for Flanders and location strategies of the Flemish Mobility Plan. The main purpose of these plans is to optimise the traffic and transport infrastructure by situating traffic-generating activities around public transport hubs as much as possible. In the empirical section, we verified whether these locations effectively attract or generate sustainable commuting behaviour. This enabled us to conclude that a location near a railway station leads to more sustainable commuting and that the proximity of bus, tram or metro stops also attracts more users of those modes of transportation. However, we have to confirm that the car is still the most important mode of transport by far. This is even the case when the offer of public transport is exceptionally good. Subsequently, the hypothesis that increasing the density of urban areas potentially leads to more sustainable commuting was tested. The data analysis took the proposed planning delineation of urban areas as its starting point. From this we were able to deduce that, compared to the average commuting behaviour of the Flemish, inhabitants of the urban areas display relatively more sustainable commuting behaviour. However, these results should not lead to too much optimism, in both the inner cities and the metropolitan areas commuting by car is still the most popular mode of transport by far. Finally, the Spatial Plan for Flanders also intends to continue grouping the economic activities in highly accessible zones. This goal was assessed for commuting sustainability by dividing Flanders into areas with a different economic density. It emerged that the commuting differences between these areas are limited.

We conclude that future spatial planning strategies that support the location of activities in urban areas and near stations and junctions of public transport, will have positive effects on commuter characteristics, in the sense that inhabitants or workers will move towards more sustainable characteristics. But we have to put this conclusion into perspective. To sum up, our exploratory data analysis tells us that, as far as commuting is concerned, the car is still the undisputed ruler as the preferred mode of transport: a little over 70% of commutes occur by car. On the one hand, car use goes up to 80% when commuters do not live in the vicinity of a railway station, live outside an economic core area or outside an urban area. This persistent use of the car is also true of those who do not work near a railway station or those who work in a location where they have to wait more than

15 minutes for a bus, tram or metro. On the other hand, for commuters who live or work close to well connected railway stations car use drops to 55% and slow traffic (by bike, on foot) constitutes the second most important mode with a market share of 15 to 20%. The use of trains for commuting purposes totals 6% on average. In areas that include a railway station with more than 150 stops, this rises to 10%. For those who work near railway stations in Brussels, this number even increases to 20%. The use of bus, tram and metro in urban areas with a very short waiting time (<15 minutes) has a market share of 8%, which drops to 1 to 3% in most other areas.

As a result, we have to conclude that only an extremely strict location policy that is focused on concentrating housing and working activities in or near urban areas, together with a very extensive public transport offer, can reduce the market share of cars with regard to commuting by 10 to 15% at the most. This percentage is rather low, and what is more, it can only be reached in a limited number of locations, in combination with considerable investments in the offer of public transport. The geographical analysis through maps shows that the opportunities for location policy are restricted to the urban areas.

In the light of these results, a number of opportunities for further research show up. From a methodological point of view, it would be very interesting to compare over time the commuter characteristics of neighbourhoods before and after the implementation of the spatial and mobility measures. Unfortunately, spatial representative data will be lacking due to the abolition of the census by the Belgian government. Currently we lobby for the organisation of a 'short form' census providing data that cannot be deducted from administrative data bases (together with commuter characteristics these are mainly housing data). The results of the present research can also help in more operational research. One proposal has to do with the provision of public transport infrastructures. The spatial analysis put forward in this paper can inspire the search, on a more detailed level, for additional locations that could benefit from new infrastructures, such as the latest tramways or improvements in the service levels of public transportation, for example the upgrading of railway stations. The question then is if investments in accessibility of selected locations would be enough in order to change commuting behaviour around these locations in a more sustainable way. Another application is found in the field of geomarketing, which includes the detailed search for neighbourhoods with a high accessibility where the market share of sustainable commuting is actually too low. Is it possible to organise some (marketing) actions in these neighbourhoods in order to convince commuters to change their habits into more sustainable mobility characteristics?

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Table 1: Commuting characteristics per type of railway station area

Location type	car (%)	≥ 2 cars (%)	slow modes (%)	train (%)	bus-tram-underground (%)	job in CBD (%)	residence and job same neighbourhood (%)	average distance (km)	average time (min)	commuters (%)
Place of residence (in Flanders)	**73**	**45**	**13**	**6.2**	**3.9**	**40**	**3.6**	**17**	**27**	**100**
Station area:										
train stops per day ≥ 300	55	26	22	10.9	9.0	69	3.1	16	29	9
150 ≤ train stops < 300	65	37	16	12.4	2.8	40	3.4	17	28	7
75 ≤ train stops < 150	70	41	14	7.8	5.0	43	3.2	16	28	16
train stops per day < 75	73	46	13	6.6	2.8	35	3.9	17	27	27
No station area	79	52	11	3.1	3.2	34	3.8	18	27	40
Workplace (in Flanders and Brussels)	**70**	**43**	**12**	**7.6**	**6.3**	**40**	**3.2**	**18**	**29**	**100**
Station area:										
train stops per day ≥ 300	55	38	10	19.5	13.6	77	1.4	23	39	29
150 ≤ train stops < 300	73	45	11	7.0	5.6	38	2.2	19	30	12
75 ≤ train stops < 150	77	44	12	3.6	4.5	24	2.8	18	29	17
train stops per day < 75	77	45	16	1.5	2.2	22	4.4	14	22	19
No station area	79	46	13	0.6	2.0	21	5.1	16	23	23

Table 2: Commuting characteristics per type of bus-tram-underground area

Location type	car (%)	≥ 2 cars (%)	slow modes (%)	train (%)	bus-tram-underground (%)	job in CBD (%)	residence and job same neighbourhood (%)	average distance (km)	average time (min)	commuters (%)
Place of residence (in Flanders)	**73**	**45**	**13**	**6.2**	**3.9**	**40**	**3.6**	**17**	**27**	**100**
Bus-tram-underground area:										
Wait < 15min	66	36	17	6.3	7.1	55	4.3	16	27	31
15min ≤ wait < 30min	74	47	13	6.0	2.9	35	4.1	18	27	26
30min ≤ wait < 60min	76	50	12	6.0	2.1	32	3.4	18	27	18
Wait ≥ 60min	77	51	11	6.1	1.5	28	2.9	18	27	11
No bus-tram-underground-stop	76	51	11	6.6	2.8	34	1.9	18	28	13
Workplace (in Flanders)	**75**	**45**	**14**	**3.2**	**3.8**	**39**	**3.6**	**16**	**25**	**100**
Bus-tram-underground area:										
Wait < 15min	72	45	15	4.7	5.9	61	3.0	16	27	49
15min ≤ wait < 30min	77	45	15	1.9	1.9	22	5.1	15	23	21
30min ≤ wait < 60min	78	45	13	1.1	1.4	19	4.4	16	23	14
Wait ≥ 60min	78	44	14	1.3	1.1	8	4.1	14	22	7
No bus-tram-underground-stop	79	45	12	2.2	1.9	17	2.2	17	25	9

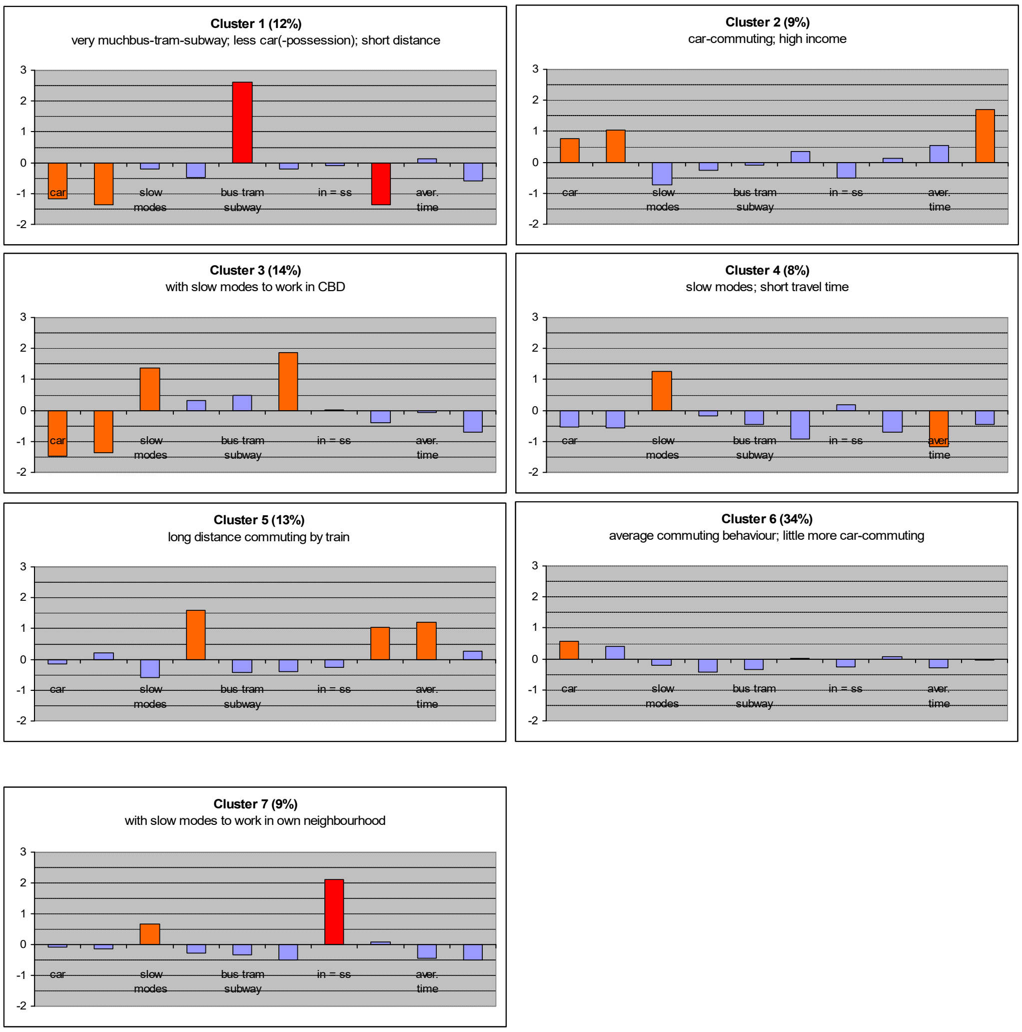
Table 3: Commuting characteristics per type of planned urban areas

Location type	car (%)	≥ 2 cars (%)	slow modes (%)	train (%)	bus-tram-underground (%)	job in CBD (%)	residence and job same neighbourhood (%)	average distance (km)	average time (min)	commuters (%)
Place of residence (in Flanders)	**73**	**45**	**13**	**6.2**	**3.9**	**40**	**3.6**	**17**	**27**	**100**
Planned urban areas:										
Metropolitan Antwerpen	65	32	15	3.4	12.3	68	2.3	13	28	9
Metropolitan Gent	61	32	18	9.0	8.6	74	3.6	18	28	5
Regional urban areas	64	36	21	7.6	3.0	55	3.5	16	25	15
Small urban areas	67	37	19	8.6	2.0	23	4.9	17	26	11
Flemish border Brussels	76	43	6	3.6	12.1	26	2.3	13	29	3
Other areas	78	52	10	5.7	2.3	31	3.7	19	28	57
Workplace (in Flanders)	**75**	**45**	**14**	**3.2**	**3.8**	**39**	**3.6**	**16**	**25**	**100**
Planned urban areas:										
Metropolitan Antwerpen	68	40	12	5.9	11.2	77	1.7	18	32	14
Metropolitan Gent	68	43	14	6.9	7.4	93	2.6	17	28	7
Regional urban areas	73	45	16	4.0	3.2	73	2.4	15	24	24
Small urban areas	77	46	17	2.0	1.5	0	3.9	13	20	15
Flemish border Brussels	86	48	4	4.5	3.6	0	1.4	26	38	5
Other areas	78	46	14	0.9	1.4	12	5.7	15	22	34

Table 4: Commuting characteristics per type of economic density area

Location type	car (%)	≥ 2 cars (%)	slow modes (%)	train (%)	bus-tram-underground (%)	job in CBD (%)	residence and job same neighbourhood (%)	average distance (km)	average time (min)	commuters (%)
Place of residence (in Flanders)	**73**	**45**	**13**	**6.2**	**3.9**	**40**	**3.6**	**17**	**27**	**100**
Economic density:										
Economic core area 1	68	38	16	6.3	6.0	51	3.1	16	27	42
Economic core area 2	74	47	14	6.1	2.6	33	4.0	17	26	20
More than local area	77	51	11	5.3	2.3	31	4.0	18	27	16
Lower economic density	77	52	10	6.8	2.2	31	4.1	20	29	22
Workplace (in Flanders)	**75**	**45**	**14**	**3.2**	**3.8**	**39**	**3.6**	**16**	**25**	**100**
Economic density:										
Economic core area 1	74	44	13	4.4	5.2	61	2.2	17	28	62
Economic core area 2	76	45	16	1.5	1.7	8	4.7	14	21	17
More than local area	78	47	16	0.9	1.3	0	5.9	13	20	10
Lower economic density	75	46	18	0.9	1.2	0	8.5	13	19	10

Appendix 1: Z-scores for commuting characteristics of neighbourhoods by cluster (Flanders or Brussels as place of residence, percentages give the share of commuters belonging to the cluster)



Appendix 2: Z-scores for commuting characteristics of neighbourhoods by cluster (Flanders or Brussels as workplace, percentages give the share of commuters belonging