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DEPARTMENT OF TRANSPORT AND REGIONAL ECONOMICS

DETERMINING FINANCIAL VIABILITY OF FREIGHT RAILWAY UNDERTAKINGS UNDER OPEN ACCESS REGULATORY ENVIRONMENTS

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ABSTRACT

In North America, railway deregulation has lowered the entry barriers and opened opportunities for private sector small to medium sized business entities (SMEs) to participate in the railway sector. This has resulted in the upward spiraling success of the "shortline" railway subsector of rail transportation in North America, which operates mostly as a closed access system.

The liberalized system of open access railways in many non-North American countries has similarly opened prospects for participation in the railway sector that were previously unavailable to the private sector.

Though there are vast differences in the characteristics of how the two systems operate, there are common elements, but careful analysis is required to determine financial and operational viability.

In this dissertation, the process of exploring European candidate routes and analyzing their financial prospects using traditional investment metrics is demonstrated by a cost simulation model, based on real costs, realistic sample revenues per loading unit and a range of operating scenarios, to understand the financial performance under a broad range of parameters.

Going beyond the financial performance of each of the eight scenarios depicted, through a combination of sensitivity analyses and detailed analyses of the costs, this dissertation identifies the most influential parameters and cost elements contributing to the financial success of a railway undertaking.

While the financial performance and influential factors contributing to profitability are identified, deficiencies and weaknesses over the railway network and indeed, the entire sector, are also recognized to determine what conditions can be optimized for overall financial and system performance to facilitate the shift of cargo from road to rail. A comprehensive analysis of tangible and intangible factors affecting railway network performance is explored and recommendations are made.

Risks to the railway sector, operationally, from a regulatory perspective and from exogenous risks are identified and suggestions are made to select optimum business models to minimize risks and increase profitability.

The results of these methods of analysis are observed, prospective solutions to industry sector problems are made and conclusions are drawn.

In conclusion, the direction of the research was to determine whether an RU entering the railway sector in the EU could feasibly operate as a stand-alone traction enterprise, without the augmentation of external or integrated complementary enterprises.

The findings distilled down to the following scenarios and under the following conditions.

- Older locomotives, either diesel-electric or electric

- Older locomotives that are homologated in multiple countries
- Negotiate a deal with the leasing companies on three different lease scenarios that equipment could migrate to, given market conditions
- T-3000 “pocket” wagons
- Start with two round trips per week, building frequencies, as market demand develops
- If able to get the operator status in all countries, ensure that done
- Have multi-lingual operating crews
- Otherwise, enter into JV agreements with other operators over and within the territories to be served, also considering expansion into other markets.

These condition combinations offer the best cases for establishing and building a successful RU enterprise in the EU, without the additional financial contribution of external or integrated complementary enterprises.

Also acknowledged and identified, in detail, are the many tangible and intangible obstacles that face RUs operating in the closed access system of North America and the open access system of the EU and/or open access environments in other geographies.

Finally, based on the research conducted herein, recommendations are made for policy, the industry and for future scholarly and academic research, along with final last thoughts.

Nederlands Abstract

In Noord-Amerika heeft de deregulering van de spoorwegen de toetredingsdrempels verlaagd en mogelijkheden geopend voor kleine tot middelgrote ondernemingen (kmo's) uit de particuliere sector om deel te nemen aan de spoorwegsector. Dit heeft geresulteerd in het opwaartse spiraalsucces van de "shortline" spoorwegsubsector van het spoorvervoer in Noord-Amerika, die meestal als een gesloten toegangssysteem werkt.

Het geliberaliseerde systeem van open-toegangsspoorwegen in veel niet-Noord-Amerikaanse landen heeft op dezelfde manier perspectieven geopend voor deelname aan de spoorwegsector die voorheen niet beschikbaar waren voor de particuliere sector.

Hoewel er enorme verschillen zijn in de kenmerken van hoe de twee systemen werken, zijn er gemeenschappelijke elementen, maar een zorgvuldige analyse is vereist om de financiële en operationele levensvatbaarheid te bepalen.

In dit proefschrift wordt het proces van het verkennen van Europese kandidaatroutes en het analyseren van hun financiële vooruitzichten met behulp van traditionele investeringsstatistieken gedemonstreerd door een kostensimulatiemodel, gebaseerd op reële kosten, realistische steekproefinkomsten per laadeenheid en een reeks operationele scenario's, om de financiële prestaties onder een breed scala aan parameters te begrijpen.

Dit proefschrift gaat verder dan de financiële prestaties van elk van de acht afgebeelde scenario's, door een combinatie van gevoeligheidsanalyses en gedetailleerde analyses van de kosten, en identificeert de meest invloedrijke parameters en kostenelementen die bijdragen aan het financiële succes van een spoorwegonderneming.

Hoewel de financiële prestaties en invloedrijke factoren die bijdragen aan de winstgevendheid worden geïdentificeerd, worden tekortkomingen en zwakke punten over het spoorwegnet en zelfs de hele sector ook erkend om te bepalen welke voorwaarden kunnen worden geoptimaliseerd voor de algehele financiële en systeemprestaties om de verschuiving van vracht van de weg naar het spoor te vergemakkelijken. Een uitgebreide analyse van tastbare en immateriële factoren die van invloed zijn op de prestaties van het spoorwegnet wordt onderzocht en er worden aanbevelingen gedaan.

Risico's voor de spoorwegsector, operationeel, vanuit een regelgevend perspectief en vanuit exogene risico's worden geïdentificeerd en er worden suggesties gedaan om optimale bedrijfsmodellen te selecteren om risico's te minimeren en de winstgevendheid te verhogen.

De resultaten van deze analysemethoden worden geobserveerd, prospectieve oplossingen voor problemen in de industriesector worden voorgesteld en conclusies worden getrokken.

Concluderend was de richting van het onderzoek om te bepalen of een spoorwegonderneming die de spoorwegsector in de EU betreedt, haalbaar als een op

zichzelf staande tractieonderneming zou kunnen opereren, zonder de uitbreiding van externe of geïntegreerde complementaire ondernemingen.

De bevindingen zijn gedestilleerd tot de volgende scenario's en onder de volgende omstandigheden.

• Oudere locomotieven, dieselelektrische of elektrische

• Oudere locomotieven die in meerdere landen zijn gehomologeerd

• Onderhandelen over een deal met de leasemaatschappijen over drie verschillende leasescenario's waar apparatuur naartoe zou kunnen migreren, gezien de marktomstandigheden

• T-3000 "pocket" wagons

• Begin met twee retourritten per week, bouwfrequenties, naarmate de marktvraag zich ontwikkelt

• Als u in staat bent om de operatorstatus in alle landen te krijgen, zorg er dan voor dat dit gebeurt

• Meertalige operationele bemanningen hebben

• Anders, het aangaan van JJV-overeenkomsten met andere exploitanten over en binnen de te bedienen gebieden, ook met het oog op uitbreiding naar andere markten.

Deze voorwaardencombinaties bieden de beste omstandigheden voor de oprichting en opbouw van een succesvolle spoorwegonderneming in de EU, zonder de extra financiële bijdrage van externe of geïntegreerde complementaire ondernemingen.

Ook worden de vele materiële en immateriële obstakels waarmee spoorwegondernemingen worden geconfronteerd die actief zijn in het gesloten toegangssysteem van Noord-Amerika en het opentoegangssysteem van de EU en/of opentoegangsomgevingen in andere regio's, in detail erkend en geïdentificeerd.

Tot slot worden op basis van het hierin uitgevoerde onderzoek aanbevelingen gedaan voor het beleid, de industrie en voor toekomstig wetenschappelijk en academisch onderzoek, samen met enkele laatste bedenkingen.

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To my friends and colleagues:

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It has been a long path and I hope that this work will represent a stable platform for present and future researchers, as well as those engaged in advanced learning and government policy.

Daniel T. Behr
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Chicago IL USA

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ABBREVIATIONS AND ACRONYMS

3PL – Third-party logistics

BRI – Belt and Road Initiative (China)

AAR – Association of American Railroads

AMTRAK – National Passenger Railroad Corporation (United States)

CEE - Central and Eastern European Countries

CFL - Chemins de Fer Luxembourgeois

COSMOS – Cooperative Solutions for Managing Optimized Services

Cp - Path (or Infrastructure) costs, by country

CR – Container rental

CREAM – **C** ustomer-driven **R** ail-freight services on a **E** uropean mega-corridor based on **A** dvanced business and operating **M** odels

C_t (TC) - Terminal costs

CT – Combined transport (intermodal)

DB – Deutsche Bahn

DFA – Depreciation of fixed assets

DIOMIS – **D** eveloping **I** nfrastructure use and **O** perating **M** odels for **I** ntermodal **S** hift

DSS – Decision Support System

D/V – Debt Value portion of an enterprise's capital structure

E – Energy costs

EC – European Commission

ERTMS – European Railway Train Management System

ETISPlus - European Transport policy Information System

EU – European Union

E/V – Equity Value portion of an enterprise's capital structure

GDP – Gross Domestic Product

FLAVIA - **F** reight and **L** ogistics **A** dvancement in Central/South-East Europe – **V** alidation of trade and transport processes, **I** mplementation of improvement actions, **A** pplications of co-coordinated structures

FRA –Federal Railroad Administration (United States)

GBFM – Great Britain Freight Model

HGV – Heavy goods vehicles

HIT – Heuristics Intermodal Transport

HP - Horsepower

HS – Hub and spoke

IC – Infrastructure costs

INSC (I) – Insurance Cost

IRR – Internal Rate of Return

ISO – International Standards Orga

IWT – Inland Waterway Transport

JV - Joint venture

kW - Kilowatt

LCL – Less than container-load

LCOH – Labor cost per operating hour

L – Lifts

LAU – Local Administrative Units (Subset below NUTS3)

L_{MD} - Locomotive maintenance, direct

L_{MR} - Locomotive maintenance, reserve

LR (L_R) – Locomotive rental

LRS – Locomotive rental, spot

LRSM – Locomotive, running maintenance

LTL – Less than truckload

LU – Loading units

M&A – Mergers and Acquisitions

MISC (C_m) – Miscellaneous. costs

NPV – Net Present Value

NST – Nomenclature uniforme des marchandises pour les Statistiques de Transport (Standard Goods Nomenclature for Transport Statistics – English)

NST2 - Nomenclature uniforme des marchandises pour les Statistiques de Transport, version 2 (Standard Goods Nomenclature for Transport Statistics version 2 – English)

NST /R – Nomenclature uniforme des marchandises pour les Statistiques de Transport / **R** évisée (Standard Goods Nomenclature for Transport Statistics/revised – English)

NUTS – **N** omenclature des **u** nités **t** erritoriales **s** tatistiques (Nomenclature of Territorial Units for Statistics – English)

O – Labor cost per hour

O/D – Origin Destination

OECD - Organisation for Economic Co-operation and Development

PKP - Polskie Koleje Państwowe SA

PPH – Pre and Post Handling

PPTMS – Pre and post-trip mechanical inspections

RECORDIT – Real Cost Reduction of Door-to-Door Intermodal Transport

RETRACK - **RE**organisation of **T**ransport Networks by Advanced **RA**il freight **C**oncepts

RNE – Railnet Europe

RNE/CIS – Railnet Europe / Charging Information System

RU - Railway undertaking

S – Sets, train

SG&A (S) – Sales, general and administrative (category of costs)

SME – Small-to-Medium-Size Enterprise

SQL – Structured Query Language

SNCF – **S** ociété **n** ationale des **c** hemins de fer **f** rançais

SO – Subcontractors, operating

STB – Surface Transportation Board (United States Department of Transportation)

SWOT – Strengths, weaknesses, opportunities and threats

TC (C_t)– Terminal costs

TCL – Total cost lifts

TCS – Total cost storage

TEU – Twenty-Foot Equivalent

TOC – Terminal Operating Company

TRACECA – **TRA** nsport **C** orridor **E** urope- **C** aucasus- **A** sia

TSH – Train shunting and handling

T_y - Trainsets per year

TTT – Total Transit (or Train) Time

VC – Variable costs

VOT – Value of Time

VSA – Vessel Sharing Agreements

WACC – Weighted Average Cost of Capital

WR – Wagon rental

WRS – Wagon rental, spot

W.R.T. – With respect to

WSH – Wagon shunting and handling

WSM – Wagon running maintenance

Chapter One - Introduction

1.1 Introduction

Railways, in the basic form known today, have been an integral component of sovereign economies around the world for over 200 years ago. In the evolving history of railways, from the initially embryonic to today's form, differing business model forms adapted separately, in response to various internal and external forces. For the US and North America, the motivations were largely about territorial development and expansion of the economy, especially for newly acquired, but unsettled and undeveloped territories. For Europe, the motivations were multiple, ranging from geopolitics and defense to domestic tranquility, through full employment.[1] Also included were the factors of commerce, external and internal, especially as regards inputs to production, such as raw and bulk material and production distribution. Regardless of the business models adopted, in the end, economic fundamentals caused railways to respond to their respective environments in the way that they have, shaping their States' internal and external transport policies, affecting national development.

This research will examine the underlying forces, primarily economic, but also acknowledging other tangible and intangible factors that determine whether rail transport of cargo will be competitive over other modes.

Examining those factors comprised of the structure of cost elements is part of the analysis. What are those elements, are they unique to railways and if so, why? Observing how and why railways developed the way they have will offer insight into subtleties that distinguish the cost structures between the typologies of railway undertakings.

In this research, the reader can expect identification of fixed and operational (variable), cost elements. The reader can also expect an overview of the infrastructure necessary to conduct transportation in today's demanding competitive environment. In addition to those fundamentals, successful companies engaging in rail transport have certain typologies, with varying degrees of vertical and horizontal integration or, in some cases, none. The research will identify and classify those typologies. The research will examine company structure options and practices. It will also analyze the cost elements, both fixed and variable, the vertical and horizontal business relationships with complementary industry players, relationships with customers and details, as to aspects of the service and operating models. Due to the proprietary nature of financial and traffic volume data from various players, it

[1] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), Page 325, *2.2 Inputs in the production of transport*, *No. 1 The factor "labour".*

may not be possible to precisely identify costs associated with individual players. Despite these data limitations, there should be sufficient data to construct a costing model applied to test case scenarios that can simulate financial performance and help answer the research question.

What will not be included will be quantification of intangible factors influencing financial performance, such as charges for externalities, as there are few established values or reliable marketplace mechanisms to assess those charges.

Also not included will be the "hidden hand" costs of political inertia interference, which, while considerable and adversely affect financial performance, are difficult to measure. Examples of these types of political and cultural impediments are:

- Structural, in that there are pre-existing and organizational administrative constructs that prevent or hinder policy execution favorable to rail, with no opportunities for railway undertakings to participate or have input into decision processes.

- Cultural, in which administration players within local jurisdictions do not cooperate and/or agree with broader policy decisions made on a ministerial or federal level favoring rail transport.

- Exogenous, similar to cultural factors, described above, in which broad policy direction on an even higher level, such as the EC, is ignored or resisted. The exogenous and the cultural factors typify the struggle and resistance against central authority, which is routinely and universally practiced around the world.

If these were factors in a SWOT analysis, they would be categorized as "political risk".

Analysis of the elements comprising the financial structure of the railways and their relationships with the enterprise will be by using a financial simulation model developed for this Ph.D. that will serve, not to provide absolute "go/no-go" answers, rather, *as general guidance and a platform for hypothetical operational scenarios*, using *any researcher-defined parameter data inputs available within realistic ranges*, to answer the research question.

1.2 Background

Over approximately the last three decades, railway operator models have changed, particularly in the European Union, where the political orientation, with its fundamental roots in a common market, has amended the traditional structure of the railway sector. The

EU's current political direction favors increased competition, harmonization, interoperability and open markets, which has catalyzed the unbundling of marketing, operations and control of the network itself. This has led to a large-scale restructuring of railway enterprises.

The rail sector, traditionally characterized as a staid, unremarkable, somewhat non-innovative and mature industry, consisting of the vertically integrated former state railways ("incumbent" railways), has, over a relatively short span of time, become thrust into a position where its costs, interlinked interests throughout its former vertical structure, from the railway network itself, with its power distribution, signaling systems and workshops, to its large rosters of rolling stock (locomotives and wagons), as well as administrative support systems, have now suddenly become open for the world to see, to their political detriment. The EU/common market philosophy has forced apart the vertical integration and beneficial scale that the incumbent railways have so long enjoyed.[2] [3][4]

Another effect of the incumbent's high costs becoming visible was a period of rationalization, the result of which further reduced rail cargo service availability. Aside from the adverse economic effects on shippers (and the economy, in general), due to poor service quality issues, another driver for political support to separate the incumbent railways from their vertically integrated components has been their historical unresponsiveness to the needs of shippers. This comes at a time when negative societal externalities resulting from transport activities have come into focus, such as climate change, congestion, emissions, noise and safety. These broad changes have provided potentially new opportunities for both shippers and entrepreneurs to fill transport needs. These changes have also resulted in considerable fragmentation of the transport sector. The combination of the above-mentioned factors and others, have, in the rationale of some entrepreneurs, led to confidence that there are new opportunities in the formerly moribund and impenetrable rail sector. Despite the apparent opportunity, there are factors that could adversely affect the sector, if not carefully researched, made known and considered.

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[2] Thompson, Lou, ***"Liberalization and Commercialization of the World's Railways – Progress and Key Regulatory Issues"***, (2009), Thompson – International Transport Forum Pages 5 – 16

[3] Maes, Jochen & Vanelslander, Thierry, ***"The Use of Transport as Part of the Supply Chain in an Urban Logistics Context"***, (2011), WCTR July 11-15, 2012, Lisbon Portugal, Pages 4 & 7

[4] Crozet, Yves et al., ***"Development of Rail Freight in Europe: What Regulation Can and Cannot Do"***, CERRE Policy Paper, (2014), Pages 18 – 19

The concept of movement towards separation of infrastructure and railway operations has not only affected the EU, it has become a trend worldwide, with numerous countries adopting the vertical separation model, ranging from Australia and New Zealand to railways in South and Central America and also in Africa.

In contrast, North America (the US and Canada), have not embraced this direction, principally because of the historical private ownership model extant since the 19th Century and the inception of railways on the North American continent. The US and Canadian governments, in the interest of developing their hinterland territories, granted private ownership to private stock companies, in compensation for their large capital costs, risks and commitments to build railways and supporting infrastructure across the continent.

Despite their relative freedom and complete vertical integration, from around the postwar period and up until 1980, the US and Canadian railways were commercially inhibited by excessive regulation, hindering them from effectively competing in the marketplace. In addition to regulatory interference, the US government created competition by developing the national interstate highway system, where the trucking sector was (and still is), undercharged for their use of the highway infrastructure, along with the development of the civil aviation sector, within which the airlines competed with the railways for both passenger, cargo and light package, as well as the postal business, ultimately leading to the demise of the privately operated rail passenger sector.

Regardless of the continent or nation, challenges, known and unknown, exist for the prospective railway operator. To the degree possible, both governments and the private sector should be made aware of the realistic business efficacy of a railway enterprise and seek to minimize financial risk.

The successful execution of business strategies is inextricably intertwined with the elements of people, process and prospects. The people element is beyond the scope of this Ph.D., but the process, in the context of the selection of business prospects, is within the objective and the research questions, to be stated further. The identification of realistic business prospects, through a process involving a replicable cost model to be developed and applied universally is the focus for this Ph.D.

Competition from other modes (as well as within the rail mode), is a perennial challenge to railway enterprises universally. Given the high fixed cost structure of railway undertakings ("RU's"), regardless of whether they operate in an open or closed access system, to achieve profitability, RU's must achieve a delicate balance between minimizing capital investment and their inherent risks with having enough rolling stock and fixed assets to ensure barriers remain to prevent new entrants into the sector, as well.

1.3 Objective and Research Questions

The overall objective of this research is to compare, contrast and analyze North American and non-North American railway cargo business models to arrive at a workable and practical business model for application to varying railway enterprise typologies worldwide.

The research question that derives from this objective is the focus of this dissertation:

Research Question:

"Under selected conditions, can the smaller scale, more entrepreneurial versions of the North American-style of traditional railway enterprise, known as the "shortline" or "regional" railway develop a profitable business model in the newly liberalized commercial market and regulatory environment in the EU, as well as in other geographies, with or without integrating complementary business elements[5] ("bolt-on"), as either separate or related enterprises?"

Further, "under what operational scenarios and conditions would a railway undertaking (RU), be profitable?" can be answered once an analytical framework is established to compare scenarios. The framework will include independent variables, such as train length in wagons, number of loading units on the wagons in the train (expressed as percentage load factor) and rate per kilometer per loading unit. The model framework will also include fixed and variable costs, along with variable revenue scenarios. Ultimately, the variability of costs and revenue will be selectable, enabling the researcher to generate empirical data for analysis.

As to why this research question is important, the motivations of prospective RU operators and investors are varied. Some may wish to preserve a link to rail transport, that they would otherwise lose, if left to governments seeking to save money by closing money-losing branches. That category of actors has survival of local enterprises and the local communities in mind as their main objective. Larger players, such as shipping companies, may wish to

[5] Examples of complementary enterprises are terminals, workshops, separate locomotive and wagon leasing enterprises, warehousing and distribution, as well as freight forwarding and for that reason, the income and expense stream of any those enterprises will **not** be integrated into the simulation model, although there are provisions in the design for later addition.

integrate land transport into their maritime services and become more competitive. Other players see market opportunities to capitalize on the neglect of those local or regional markets by larger players, such as the former incumbent RU's or the Class I railroads in the US. By paying attention to those neglected markets, the shortline railroad entrepreneurs have prospered and grown. Answering the research question as to whether it is possible to apply the North American shortline approach to open access markets opens up new market opportunities and facilitates the policy goals of shifting road to rail. Regardless of the internal motivations, an analysis platform of prospective routes is a prerequisite in the decision to establish rail service offerings to the market.

1.4 Theoretical Basis of Model Approach

The underlying basis of the analysis framework and model approach came more into focus after the literature review of the models to apply to the data. As a general truism, there is a linkage between volume of transport and economic activity using GDP as an indicator. However, as a predictor of transport demand, general aggregate demand analysis is inadequate and does not consider the mode characteristics and attributes of the cargo, nor does it consider the nature of the territories of the O/D pairs, with respect to determining the proportion of the industrial sector comprising GDP. Also, aggregate model approaches do not consider individual cost elements of the transportation process, in comparison to disaggregate models, which do so. [6] For those reasons and other factors, the activity-based engineering cost simulation model was adopted. **Section 2.7.2 - Costing Models** and **Chapter 4 – Methodological Framework** show details of the process used to arrive at that solution.

Chapter 2 - Literature Review

The general guidance for research selection was to distill from the literature, an overview of the marketplace and competition that would define the variations of railway operator typologies and their factors for success.

Equally important were identifying obstacles that prevented financial viability, the reasons the obstacles exist, strategies to compensate or circumvent and therefore remedy those problems.

From the literature, success (and failure) factors, obstacles and survey of business conditions, operating factors and "on the ground" realities, successful typologies and their

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[6] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), Pages 310 - 315

variations emerged for study focus. Relevant data elements were recognized, as to which to include as factors to consider in building a costing model.

Within the literature review, reports, studies, papers and PhD dissertations that were influential and whose analyses played a role in the development of this PhD research were included. The chapter will also cover other questions that emerged that were not covered by the literature.

The objectives of this PhD research are that it will help RUs, their complementary services providers, customers, government and regulators, as well as other researchers gain perspective into the factors that contribute to creating opportunities to ensure effective market positioning of the railway enterprise, e.g., market share, hence financial success of RUs, as well as a more prominent role in the general economy. The research will also highlight industry sector weaknesses (both secular and cyclical), illustrating exposure to commercial, as well as political (policy) risk.

Chapter 3 – North American Closed Access vs. Open Access Business Models

In this chapter, the differences between the North American closed access and the open access railway business models are presented. While the North American railway operators may be burdened by heavier capital expenditure costs because rail operators maintain their own infrastructure, they are not burdened as much as open access rail operators by still heavier regulations, high labor, energy and network access charges, as well as the hidden hand of competitive former incumbent railways, operating through governmental and regulatory proxies.

The respective networks have different characteristics, in that there are generally (except for Australia), shorter distances between and within most open access countries, hence more line or corridor density, than in North America. Weight, dimensions and capacity of railcars also play a role in efficiencies, as does the ability for North American railways to "double-stack" containers, due to less restrictive loading gauge and axle weight constraints, compared to many open-access countries, particularly in Europe.

The cost, revenue and capital structure accounting approaches and practices are compared.

These factors are explored in examining the cost structures of North American railways vs. open access railways elsewhere.

Also included are identification of railway undertaking typologies and attributes, drawn from the insights gained from the research covered in the literature review. In the context of the research question, the various typology characteristics will be reviewed and those assessed to have the most and characteristics of highest commercial viability will be selected for cost modeling. The characteristics of commercial viability will especially address those RU typologies that target high value and/or time sensitive traffic that is most often transported by road and which has a high potential for both revenue and volume growth.

Chapter 4 – Methodological Framework

To help answer the research question ("…under selected conditions") "*Is it possible to develop a profitable business case to participate in the newly deregulated and liberalized rail cargo sector in the world over selected freight corridors and/or line segments?",* cost analysis would be at the basis of a decision to provide rail transportation services to the sector.

The methodology would be predicated on the availability of data to support the method chosen. There are, fundamentally, two methods of cost analysis:

1. Statistical
2. Engineering

If a database of historical observations with a sufficient level of disaggregation with time-series or cross-sectional data was available, one might consider the statistical method, developing econometric cost functions. On the other hand, if a researcher were to analyze the production processes of conducting transportation and would have the data to break down each operational element into directly attributable costs, defined as per kilometer, per kW, per unit of time and the like, then one would have the core elements needed to calculate, on a granular level, the unit cost per operation over the continuum of a selected route or set of routes. Fortunately, this data was available to this author and for that reason, the engineering method of cost analysis was chosen. [7]

Given the above decision process, a costing model was developed, with universal elements common to most railway undertakings. This costing model is intended to be applicable to railways operating in similar deregulated and liberalized environments and will be broadly applied to selected railway corridors, defined further in this dissertation.

The overall model will be a hybrid of a cost simulation and an engineering model. The engineering elements of the model will include cost simulations and assess the costs of prospective operations over a route, given a sample matrix of O/D pairs. While measuring

[7] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), Page 323

every O/D pair along the route, with its commodity combinations is beyond the scope of this research, the methodology framework would be established to conduct such an analysis for application for further research on or within these or other corridors.

This would mean that a cost structure template would have to be developed for the specific corridor(s) selected and integrated into the model.

Corridors will be identified that consider consumption, production and traffic generators, such as seaports, terminals, warehousing and distribution centers, as well as manufacturing and processing centers. In the selection of corridors, the element of traffic volume balance in both directions, to the degree possible, of the examined corridors will be considered for optimal economics.

In summary, what factors lead to a viable business model?

Although the methodology is intended to be generally applied to all railway typology structures, with a focus on selected parameters, the route viability can also be influenced by factors within the marketplace, such as demography, economic clustering and activity, industry sector forces (fragmentation and consolidation), regulatory and political / administrative environment and network factors. While these factors will not be measured, their influence will be separately acknowledged through research in further section SWOT analyses templates.

The analytical (sensitivity analysis), portion of the methodology will analyze the data that the blended engineering model portion generates from each permutation of the operational scenarios to help identify the most influential parameter combinations on profitability.

The framework described in this chapter will be used to analyze the data in the form of modeling scenarios, described below, as steps in analysis to be covered in **Chapter 6 – Financial and Risk Analysis.**

Chapter 5 – Empirical Use of the Cost Model

Data, Variables and Structure

Data availability and quality has proven to be a persistent problem in this research. Much of this chapter will address the shortcomings of data and how relevant data might be reliably extracted. The level of detail collected, especially at a disaggregate level, has diminished in recent years.

The type of traffic volume targeted is classified as "intermodal", is defined as *"Movement of goods (in one and the same loading unit or vehicle), by successive modes of transport without handling of the goods themselves when changing modes"* by the Organisation for Economic Co-operation and Development (OECD).

The flow of cargo forms the basis for any revenue projection in a transport enterprise. However, to develop such a model, useful cargo movement data to address the objectives is not available in sufficiently disaggregated form. While there is limited data available from the ports and Eurostat on an aggregate basis, data with the necessary level of detail does not exist in public domain. This level of data likely exists, albeit in proprietary form with the various actors within the typologies of transport enterprises, such as freight forwarders, railway undertakings (RUs), ports and shippers, but for obvious competitive reasons, will unlikely be revealed or shared.

Also problematic is that within Eurostat itself, the level of detail available has become less, over time. Since part of the core tenet of the EU is to establish a common market, the member states' respective customs offices no longer record transit flows between EU states. Adding member states to the EU has resulted in Eurostat's movement towards standardizing ("harmonizing") data, which has resulted in a trend towards a reduction of the detail in data collected and thus has rendered Eurostat a less useful tool.

These questions will be explored in greater detail within this chapter.

Acknowledging that in specific cases within typologies, there are unique data elements and sources, there are certain variables that are common to all enterprise typologies. Those variables will be defined within this chapter.

The traffic data and costing model drew from the resources listed below:

- Eurostat
- Custom data from other studies conducted by academic researchers
- Costing elements, self-sourced and using the Delphi method

Industry trade organizations consulted for either confirmation and/or additional data drawn included:

- Association of American Railroads (AAR)
- American Short Line Railroad Association (ASLRRA)
- CargoStat – K & P Transport Consultants

- CER (Community of European Railway and Infrastructure Companies)
- CLECAT (European Association of Forwarding, Transport, Logistics and Customs Services)
- European Intermodal Association (EIA)
- Hinterlandport.eu
- UIRR (International Union of Combined Rail Road Transport Companies)
- UNIFE (Association of the European Railway Industry)

For reality checks, sources and contacts within related sectors, such as railway, freight forwarders, terminal operating companies, marine, warehousing and distribution and trucking will be consulted, as available, to get a sense of what is operationally normal, general truths and rules of thumb used in the course of conducting everyday business, as well as realistic boundaries in observed data. Data gathering from these sources is classified as the “Delphi Method”.

For analyses of both costs and revenue, a simulation model will be selected.

Costing data will draw from a compilation of the individual cost elements that comprise rail and terminal operations on as low a level as possible to enhance accuracy. This will entail examining potential operations in a range of EU countries, consistent with the candidate corridors being contemplated. The cost elements to be included in the costing model fall into the broad categories within fixed and variable costs.

Chapter 6 – Financial and Risk Analysis

Using the methodological framework defined in Chapter 4, this chapter will analyze the data, controlling for non-bulk commodities being hauled in containers or trailers between O/D pairs selected by criteria of having a seaport at least one end and a production and/or consumption region at the other end. To be clear, the specific commodities targeted will not be the traditional commodities hauled by rail, such as bulk chemicals, ores, metals, grain, timber, cement, stone, sand, coal and the like, rather, those commodities that have the highest probability of being hauled in loading units, such as truck trailers and containers.

Once the O/D pair(s) and region(s) are identified for the type and volume of traffic sought, the costing model will be applied, as applicable to the O/D and corridor selected.

The analysis is expected to be an iterative process, as variations in results are anticipated. The steps in the process will be:

a. Calculate all combinations of revenue, given the parameters of price per km, number of wagons in a train, load factor of the train and number of trains operated
b. Initial calibration
c. Validation
d. Final interpretation of results

The cost analysis portion of **Section 6.7** describes the application of sensitivity analyses, and further in **Section 6.8** as applied to the energy and path cost categories for each of the scenario cases. The analysis of each of those independent variable cost categories for each case scenario is demonstrated graphically in this chapter.

Chapter 7 – Conclusions

Key success factors are noted in this chapter, considering the differences between the respective business models in North America and the EU. Chapter Seven will conclude with tying together all the factors observed, with analysis of the selected service and operating models in the rail subsectors identified to be analyzed, to arrive at the optimum combinations of infrastructure, geographic coverage, terminals served, traffic density, line segments linking terminals vs. heavily traveled corridors (and secondary line segments). To the degree possible, the research surveyed observed and anticipated changes in regulatory environment, along with present and potential future emerging modal competition. In addition to the base transportation service model, the business models will review complementary additional sub-sector enterprise models. The combination of standalone vs. sub-sector combinations and whether they are necessary, will contribute to the spectrum of strategy options for business model variations. Given the above-mentioned elements, the conclusions will assess RU commercial viability, based on demand, expressed as traffic volume by loading unit. The model will assume variable levels of traffic flow, based on the number of trainsets operated, wagons per train and load factor percentage. Wagons per train, load factors, rate per kilometer per loading unit and number of trainsets operated will be user selectable on a spreadsheet costing tool with slide bars and/or fields to flexibly select the values for any combination of variables for each scenario and even as granular as monthly revenue, in the matrix of case scenarios. To complete an "open-eyed" and balanced perspective of RUs operating in both the open access environment, such as in Europe and the closed access environment, as in North America, sections on ***"Where is the Devil"***, as regards RUs in Europe and "***Failure Factors"*** for both environments will be presented in this chapter. Lastly, from the research within this dissertation, there will be recommendations for policy, the industry sector and recommendations for additional scholarly and academic research, using this platform, with some final thoughts from the author.

Appendices

Appendices will provide supplementary information with the underlying formulae and analysis detail.

Chapter 2 – Literature Review

2.1 Introduction Section

This chapter highlights selected research projects, industry reports, papers, books and dissertations that were influential and helped establish the basis and context for developing the research question.

The foundation underlying the research question was made by examining selected research work that had been conducted on the topic of viable business cases for railway cargo enterprises. The literature provided guidance, as to the structure, information sources, analyses methodology and depth of content, as well as insight into the rail sector's organization and underlying cost drivers for analysis within this dissertation.

Therefore, research relevant to this dissertation was literature to understand and be able to explain the market forces, constraints and conditions, physical infrastructure limitations, evolving enterprise typologies and political factors affecting railway undertakings (RUs). These factors affect RUs by driving costs. Costs affect market position, identify challenges and point to strategies that RUs may need to implement to achieve and maintain competitiveness. The following is a non-exhaustive overview of the literature that was the most influential to the objective of this dissertation. These works were selected because they are relevant to this dissertation and explain the practical and real "on-the-ground" considerations that go into determining the economic viability of rail cargo operations, as well as the industry sector overview, intangibles and theoretical underpinnings. These factors and their effects on various typologies helped determine strategies for railway undertakings. The following research is broadly organized by themes.

2.2 Typology - Desirable Overall Corridor Attributes, Targeted Traffic & Network Characteristics

The PhD research work of Grosso (2011) explains the intermodal transport sector and the relationships between the players within. From the outset, she distinguishes between intermodal transport driven by geography, political and infrastructure reasons and intermodal transport driven strictly for economic reasons. In this dissertation, the use of intermodal driven by economic reasons is examined.

Relating to intermodal rail transport, high fixed costs characterize this subsector through terminal and infrastructure costs, with relatively low variable costs, if the RU is operating a terminal, integrated with supplying traction. Grosso's research suggests the distance point that makes sense to shift from road to rail is approximately 5-600 km, but less – 250 to 300 km, if the route is to / from a port, where the volume of traffic compensates.

Grosso sees the pattern that many operators achieve economies of scale by operating between maritime and inland terminals, often within the same country. Grosso further observes that many RUs are also often subsidiaries of larger, integrated enterprises, such as shipping lines, terminal operating companies or smaller size RUs, operating on behalf of larger transport operators. Exceptions to this are large shippers, that operate either on their own behalf in conjunction with freight forwarding companies, often "in-house" operations.

That view is supported in the paper by Macharis and Pekin (2013)***,*** as consistent with the concept of aggregating traffic to achieve scale. The main thesis of this research is that seaports are a natural point for developing intermodal traffic, both as an extension of the port to the hinterland, as well as increasing the efficiency of the transport sector, in the abstract. The research posits that the biggest opportunity for railway modal share increase is through intermodal traffic. Since a large amount, approximately 60% of intermodal traffic travels internationally along established corridors, the nature of this traffic is for long distances, which makes it better suited for rail transport. Due to this, rail transport is an asset that can solve the problems of congestion in the port areas with its negative social impacts and economically provide transport to final destinations.

The research paper Tawfik, Mostert and Limbourg (2015) [8] makes similar points that when there are small pre- and post-haulage (PPH) distances involved in transport, intermodal transport becomes more competitive, when external costs are internalized, with respect to distances. When there are longer PPH distances involved, the opposite is true, leading to a longer distance needed to achieve breakeven costs. This is particularly important in Belgium, where drayage costs account for 25 – 40% of the total transport expenses and economies of scale are not reached, due to the short distances of a substantial portion of the total traffic. There are varying opinions on the distance points at which rail is most advantageous for modal shift. For determining breakeven distance, defined in this context as the distance point at which rail intermodal transport becomes more competitive than truck transport only, the costs of which for both at the breakeven distance point are equal. There are generally two methods to determine that point. Macharis and Meers (2014)

1) Collecting empirical price data from sources such as Transportation Intelligence (Ti Upply), a research firm in the UK that publishes both average prices per km for trucks regionally and focusing on a specific trade lane.

2) Modeling the general internal cost structure of both transport chains.

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[8] ***"DELIVERABLE 1.1 - 1.2 B: What is the role of costs in transportation mode competitiveness?",*** Brain Trains (2015), pp 18 – 29

The research of Janic (2007) uses method 2 and posits that beyond a certain km trip length, freight train costs go down faster than road costs and for strictly internal costs, that point is 600 km. Curiously, according to Janic, the average internal operational cost for truck is lower than intermodal, because it includes the door-to-door trip segments. The paper is vague, as to the reasons why there are lower truck prices, stating *"...in combination with other market and regulatory factors, leads to lower prices"*. The lower prices, of course, attract shipper interest, especially for price sensitive and/or light, but with high cubic capacity consumption. That point coincides with approximately 90% of traffic around 600 km. But both modes depend on the actual door-to-door distance. For a long-distance truck haul, the average internal cost decreases disproportionately more, especially if door-to-door distances increase, either by truck or rail. Since the internal costs of road or rail (intermodal) trip include door-to-door, the point at which increased distance economies begin to exceed rail is approximately 900 km. It would seem counterintuitive that rail would, at a longer distance, be less economical than truck, but this is because rail intermodal must also factor in the truck segment from and to the door(s) at the origin and destination. [9] From other research, Janic focused on longer distance intermodal trains, from the standard length (***Conventional Intermodal Freight Trains – (CIFTS)***, to longer versions of the same train, referred to as ***"Long Intermodal Freight Trains (LIFTS)"***, which operated over corridors of between 900 - 1100 km.[10]

The breakeven points for intermodal rail are over a wide range: 200 - 400 km Ministrie van Verkeer en Waterstaat (1994), 500 km van Klink and van den Berg (1998), 350 km Kombiverkehr (2004), 600 - 1050 km Janic (2007 -2008) and 600 km Kreutzberger (2008)[11]

For freight transport market segmentation, CE Delft considers the freight market segmented into short and long distances of <500 km and >500 km, respectively.[12] Interestingly enough, den Boer et al. (2011), calculates that load factors for both freight trains and trucks hauling containers increase by 25% and 32%, respectively, expressed in tons/vehicle for trips >500 km vs <500 km. (See Figure 1)

Blauwens (2020), in defining the methodological framework of aggregate models for freight shippers, writes that the characteristics of the trip are important in determining the transport

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[9] Source: Janic, Milan, ***"Modeling the Full Costs of Intermodal and Road Freight Transport Network"***, Transportation Research Part D (2007), Pages 41 - 43.

[10] Janic, Milan, ***"An assessment of the performance of the European long intermodal freight trains (LIFTS)"***, OTB Research Institute, Delft University of Technology, (2007), P.1327.

[11] Source: Macharis & Meers, ***"Modal Choice in Intermodal Transport"***, UA/TPR (2014).

[12] den Boer et al., ***"Potential of Modal Shift to Rail Transport"***, Delft (2011), Page 16, paragraph 1.

mode and that *“the most significant variable in this respect is distance. The average distance covered per ton is the highest in rail traffic”*. [13]

Occupancy rates and load factors[1]

<table>
<tr><th>Modality</th><th></th><th>Unit</th><th><100 km</th><th>100-500 km</th><th>> 500 km</th></tr>
<tr><td>Passenger car</td><td>Private</td><td>pass/veh</td><td>2.0</td><td colspan="2">2.3</td></tr>
<tr><td></td><td>Business</td><td>pass/veh</td><td>1.2</td><td colspan="2">1.1</td></tr>
<tr><td>Passenger train</td><td>Private</td><td>pass/veh</td><td>128</td><td colspan="2">147</td></tr>
<tr><td></td><td>Business</td><td>pass/veh</td><td>128</td><td colspan="2">147</td></tr>
<tr><td>Truck[2]</td><td>Containers</td><td>tonne/veh</td><td colspan="2">4.7</td><td>6.2</td></tr>
<tr><td></td><td>Bulk</td><td>tonne/veh</td><td colspan="2">7.3</td><td>7.9</td></tr>
<tr><td></td><td>Miscellaneous goods</td><td>tonne/veh</td><td colspan="2">4.3</td><td>5.8</td></tr>
<tr><td>Freight train</td><td>Containers</td><td>tonne/veh</td><td colspan="2">352</td><td>440</td></tr>
<tr><td></td><td>Bulk</td><td>tonne/veh</td><td colspan="2">379</td><td>470</td></tr>
<tr><td></td><td>Miscellaneous goods</td><td>tonne/veh</td><td colspan="2">352</td><td>448</td></tr>
</table>

Note: These load factor and occupancy figures differ from the Eurostat statistics. In the capacity study we stick to statistics, which we assume to be more reliable.

1 No occupancy rates are available for air transport.

2 Load factors are for 2020; there is a slight increase towards 2050.

Figure 1: Occupancy Rates & Load Factors

Source: den Boer et al., ***“Potential of Modal Shift to Rail Transport”*,** Delft (2011), Page 18, Table 4

In the SWOT analysis contribution to **BRAIN-TRAINS (2015),** the main points made in this paper are:

- Strengths come from higher payloads of loading units e.g., containers, along with higher capacities for transport of those loading units, in conjunction with lower costs (operational and external, if calculated), for longer distance intermodal transport
- Weaknesses come from lower quality service, in terms of travel time and reliability for the customer (shipper), higher PPH costs in high density geographies, inflexibility with railway operations and the elongated time needed to establish new rail and intermodal service.
- Opportunities derive from the ability to aggregate traffic flows, operate long(er) and heavier trains, theoretically enjoy smaller PPH radiuses (assuming terminal density in a

[13] Blauwens et al., “***Transport Economics***”, Seventh Edition (2020), Page 304, No. 2

region) and, in contemplated development, standardization of railway rolling stock, signaling systems and loading units. [14]

- Threats arise from a non-seamless operational and informational flow between the participants in the conduct of transportation, failure to consolidate traffic flows, either not enough or too large a concentration of terminals, in either case, leading to lack of bundling and/or longer PPH, affecting competitiveness of intermodal transport by rail

Building on the points made in the literature regarding a focus on container traffic, the PhD research work of Markianidou (2012) developed a methodology for converting freight traffic potential into practical and tangible units starting from trade flow and trade value data and converting into actual container flows. Her work assigns linkages from product categories and actual container flow, developing formulae for predicting traffic levels of different commodities transported by container. This work is relevant to this PhD because it addresses some of the fundamental elements in transport business models, in that it directs the focus of what traffic e.g., categories of cargo to target to make a credible business case.

This methodology is useful, in that it is possible to identify specific cargo groups that have higher possibilities for modal shift from truck to rail. However, as regards data, both Grosso and Markianidou report the same experiences this author has had with data from Eurostat that is not sufficiently disaggregated, detailed, incomplete and often out of date.

Apart from targeting specific cargo most likely to travel in containers and optimum distance corridor attributes, from a network perspective, there are variations of network typologies to consider. These typologies are advocated by Kreutzberger et al. in **"Twin Hub Networks",** (2014)**,** in which the objective of this research is to broadly identify ways to build scale and efficiency into rail transport service through consolidating or "bundling" traffic into different variations of rail cargo service, other than for direct train services from a fixed pair of terminals that already have the scale necessary for good operational (frequency) and financial performance.

In the abstract and at its core, the concept of building scale makes sense. This research examines the ways hub-spoke (HS) bundling can be accomplished through various hub and train configurations, as well as operational variations. Optimum network configurations between terminals and hubs are suggested, which include:

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[14] Though there are different types of emerging technologies that could be applied further in this dissertation, but there is no consistent standardization, as in conventional rail-road operations. The most conventional standard technology was used for simplicity.

- Fork networks – a good choice for longer trains (1000 – 1500 meters)
- Line networks – higher number of terminals visited, but same number of transshipments per load unit as direct services
- Hub-hub – similar to direct train service from a fixed pair of terminal nodes
- Hub-non-hub – from hub to terminal node and dispersion for final mile delivery
- Non-hub to non-hub – terminal node to terminal node – usually associated with a direct train service network (begin and end nodes)
- Gateway terminals – connecting separate trains at their origin and destination terminals (with ending terminal often known as the "gateway terminal")

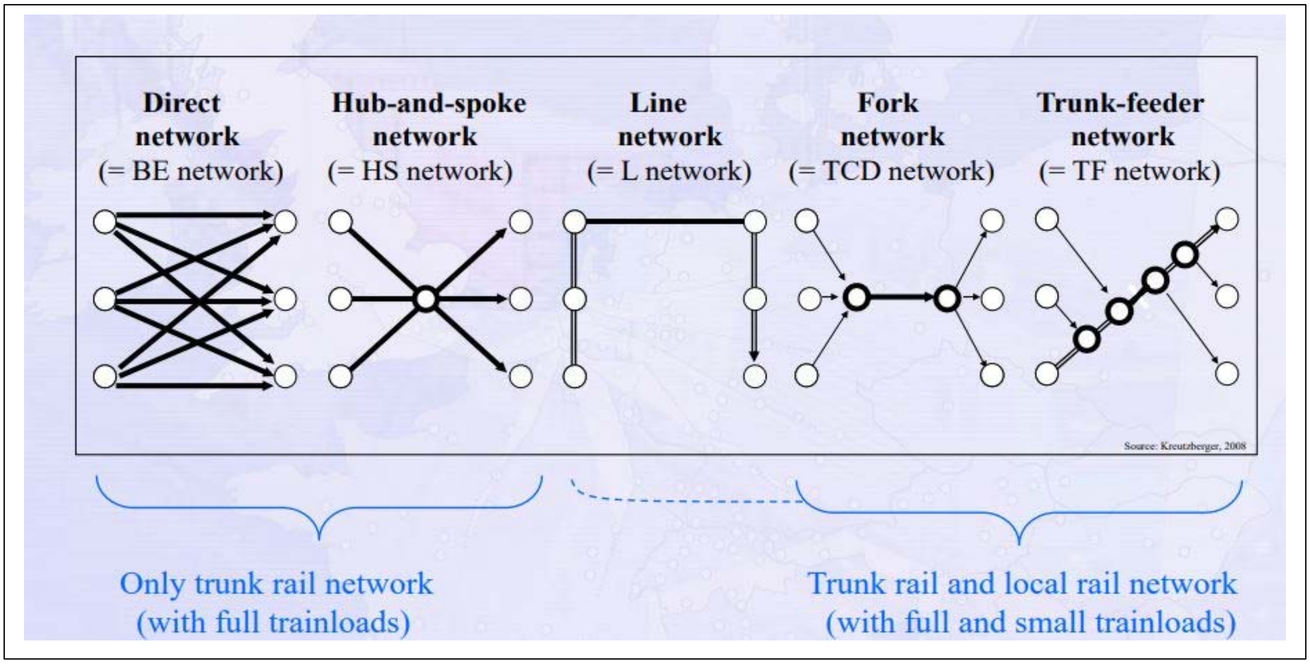

Figure 2: Sample Basic Network Configurations between Terminals & Hubs

Source: Kreutzberger (2011)

The OECD discussion paper Van de Voorde and Vanelslander (2009), reinforces the point that in order to assess the suitability for a corridor candidate for optimum possibilities for modal shift to rail, the examination of critical traffic origination and termination nodes, in the form of ports is necessary, as they are a strong driver in the nature of the relationships between players that move traffic to and from ports, e.g. the rail and truck operators, as well as freight forwarders and the steamship carriers.

The takeaways drawn from this literature section are the following:

- In general, longer distances between O/D pairs make a better case of shifting intermodal cargo from road to rail, with the threshold being >= 500 - 600 km
- Economies of scale can be achieved with greater certainty if the traffic originates or terminates between maritime terminals and the hinterland
- Becoming or being either integrated or somehow included with a large, integrated transport enterprise achieves economies of scale for intermodal traffic favoring rail
- The broad category of traffic volume to target are commodities that are most likely to be transported in a container or truck trailer
- Multiple terminals within close proximity to each other offer opportunities to bundle traffic to achieve scale [15]

2.3 Political and Institutional

Intangible elements, such as common political and institutional problems faced by railways of typologies, other than current and former state RUs around the world are also relevant. Dablanc (2008) offers this perspective.

In addition to quantitative data, Dablanc offers that qualitative data is necessary for the complete view. Dablanc's perspective is insightful, in that it identifies some of the formidable and discouraging challenges that RU operators and railway freight customers must confront within the French political, operational and to some degree, the business environment, if they wish to use railway freight services in France. For this dissertation, it is useful in comparing the direction, methods, problem solving approaches and policy philosophies of functionally similar political jurisdictions in both North America, in Europe and elsewhere. However, similar problems are not unique to France and are experienced universally by RUs around the world.

As recognized within Dablanc's research and the **REORIENT study (2007)**, that despite the EU policy of liberalization of the rail freight market, regulatory and financial barriers remain high, inhibiting competition and economies of scale that would contribute to efficiencies.

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[15] It could be argued that the point of multiple terminals in close proximity to each other represent a threat, in the sense that more terminals dilute the concentration of traffic and therefore diminish opportunities to generate scale. However, this is a normal condition of competition between terminals. Often, terminals will drop their costs to enhance their competitive position, relative to other nearby terminals, with the objective of attracting more traffic throughput and building scale through volume consolidation.

In the same context, Crozet (2014), states his perspective succinctly thus, *"Having been for a long time and very often still being the main or sole shareholder of the incumbent operator, each national state will tend to interfere in the competitive game, albeit in an indirect or hidden way. This is a delicate issue that regulators cannot always deal with head-on, yet it needs to be addressed, taking into account the independence typical of the academic world"*. [16]

In **BRAIN-TRAINS (2015)**, this research adds further points, as to the intangible factors involved with cargo by rail:

- **Structural determinants**
  There are pre-existing procedures and organizational structure that have inhibited smooth policy execution. Due to established and traditional deliberate methods of decision making, though somehow expected by some, an overall policy procedure methodology was never developed. Because of this, those whom the policies most affect have no input or participation in the decision process.

- **Cultural determinants**
  The national level political actors expected that the policy direction handed down to the regional level political actors would be acted upon. The regional actors, in turn, may either not agree with the direction(s) and/or do not recognize the authority of the federal actors to impose national and central actions on their regional and local domains and do not cooperate.

- **Exogenous determinants**
  The EC has historically been seen as inserting itself and its policy directional views into more local venues. Those transport policies are, by their nature, holistic and all-encompassing macro views, which local and national actors do not necessarily share. Thus, there was little coordination between the transport modes and perhaps even resistance on a regional and local level. In turn, the regional and local level players simply operate as they always have, which is autonomously and wish to continue that practice.

These intangible factors are important, so as to recognize the invisible hands that restrain cargo shift to rail and for later research, as to how to counteract these forces.

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[16] Crozet, Yves, et al., ***"Development of Rail Freight in Europe: What Regulation Can and Cannot Do"***, CERRE Policy Paper, (2014), P. 21

2.3.1 Institutional

In terms of other political and institutional barriers to the RU participants, the National States have adopted their own versions of adherence to compliance with the sector liberalization provisions of 91/440/EEC.

To start with background, the freight railway sector's aggregate turnover was around €15 billion vs. trucks with €300 billion in 2014 or only 5% of the truck mode.[17] Secondly, rail's modal share in the EU ranges from 12% – 30% vs. generally75% for trucks. This translates into relatively little impetus to apply to priority treatment in the political process. (Laroche et al., 2016). Thirdly, rail freight averages approximately 19% of railway traffic in Europe (Laroche et al., 2016), resulting in network slot priority favoring passenger rail. This has negative implications for the quality-of-service delivery to customers, in terms of reliability and timeliness. The lower order of priority manifests through passenger rail receiving most of the benefits of network infrastructure investments, with almost none going to improve freight rail, apart from exceptions, such as the Betuwe Line in NL, linking the Port of Rotterdam to the border of Germany in 2007. (Laroche et al., 2016).

Aside from disadvantageous access to commercially desirable network slots, non-incumbent RUs pay generally higher access charges, except for Sweden, Norway, Denmark and the UK. Because the incumbents generally have a monopoly for passenger services (and are supported with public funds), they can better afford high access charges. This disproportionately disadvantages the new entrant/non-incumbent RU and could also be interpreted as strategic behavior by the incumbents working cooperatively with the infrastructure managers (IMs) to maintain high barriers for RUs competing with former incumbents.

According to European Rail Freight Association (ERFA), they observe:[18]

- IMs refuse or offer unattractive train paths to new entrants (long running times, bad time slots, etc.
- IMs Increase access prices on routes used by new entrants, which hits newcomers harder than incumbents

These points could be difficult to prove and the difference between what an infrastructure charge could be the degree to which a national state is willing to pay for fixed infrastructure

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[17] Source: Eurostat http://ec.europa.eu/modes/road/news/road-haulage-report_en.htm via Laroche et al., ***"Brain-Trains – D52.: Scenario 1"***, (2017), page 5

[18] ERFA,***"Private Investments into Rail – What Framework Conditions?"***, European Rail Freight Association, 2014, page 3

costs vs charging a marked-up cost above the actual cost. However, *"under European legislation, access charges are to be based on direct cost, with non-discriminatory markups permitted, when needed for financial reasons"*.[19]

There are remedies to reduce the major cost disadvantages of rail expenses, specifically infrastructure charges and high energy costs. There are two approaches: 1) diminish the costs of energy for rail freight 2) reduce infrastructure costs for rail freight. Both would contribute to narrowing the other advantages of trucks. There is discussion about "incentives" applied to the road sector to further promote the cost advantages of rail, but the euphemism "incentives" means increasing taxes, tolls and fees on trucks and is not necessarily beneficial, because those increased costs would simply manifest through higher prices for anything transported by trucks.

Additional longer-term measures include coordinated policy to achieve the aims of modal shift.

Such measures are:

1. Establishing infrastructure network performance metrics and goals, with penalties for poor network accommodation to freight rail, such as delays or unfavorably distributed slot allocation to rebalance the currently more favored treatment to passenger rail.

2. Establishing a dedicated government agency whose existence and presence of the agency would help build confidence of the freight rail sector, by demonstrating permanence to implementing transport policy, at least consistently and reliably, if not favorably to freight rail, coupled with stable funding.

3. Establishing comprehensive transport policies, promoted and implemented by the agency to develop incentive and disincentive techniques to promote freight rail.

4. Linked with the above, to position the agency as an "honest broker", in the form of an intermediate between pronounced government policy goals, but taking the characteristics of the marketplace into account. A strong and independent agency would help give confidence to the independent RUs that there was a larger public body on their side vs. being overwhelmed by a large government transport ministry, influencing (naturally, with their assent), an incumbent RU to implement policies and operating practices adverse to the independent RU, but favorable to the incumbent, thereby offsetting efficiencies an independent RU may have to be more competitive.

[19] Crozet et al.,"***Development of rail freight in Europe: What regulation ca and cannot do***", CERRE (2014) P.28 - 29

5. The agency would have the power and influence the IM (if they're not the IM themselves), to suggest financial incentives more in line with allowing independent RUs to develop market opportunities more attractive to shippers. This would come in the form of discounts on infrastructure charges and/or assistance in securing priority network slots to capture the business, enhancing their service and value proposition.

2.3.2 Market Concentration

A primary objective is to increase the number of independent RU operators and build volume. Operators are attracted by ports and potential traffic, but they are not going to be attracted to a market that is dominated by an oligopoly or a monopoly. If independent RUs are not attracted to the sector, then freight rail traffic will not grow, because there would be no incentive to invest in an RU under such market conditions, countering EU policy for modal shift.

There is a problem for non-incumbent RU's entering a national (country) market if the barriers to entry are high and under conditions of a high concentration of larger players having scale. A rational, competitive response of larger RUs to the entry of smaller independent RUs would be to reduce their rates, combined with capitalizing on their scale efficiencies and overall performance to diminish any competing advantage of an RU's lower costs and more flexible crew work rules, along with any marketing initiatives that the new entrant RUs may have.

In overview, market concentration can create conditions in which a small oligopoly, intra and internationally, indicates lower profit by larger players (because they want to keep rates low to offset the efficiencies of the new, independent RUs), and is indicative of the characteristics of low competition and high entry barrier market environment.

From the perspective of the policy makers, regulatory authorities or RUs contemplating entry into a geography, a market concentration analysis is advisable. The research work of Laroche et al., (2016) in the form of **Brain-Trains Deliverable 5.3: Scenario 2**, outlines the basic analysis framework. According to this research, market concentration is determined through analysis of market structure within National borders (intra-nationally), such as within Belgium or it could be transnationally, as in inter-European.

Selection for qualification in the analysis are active RUs that are non-integrated (because it is difficult to separate the rail activities of an integrated company from its other activities), that, in aggregate, represent a majority of the market turnover (>50%), have both incumbents and new RU entrants, that time series data is available and that the activities measured are for rail freight only.

Eurostat data is too aggregated to be useful and does not include revenues, EBITDA, labor cost, freight ton-km (also from RU websites and/or annual reports), etc. by RU and UIC data is from incumbents, but not the smaller RUs. Therefore, for more detailed financial data, the Amadeus database of 21 mm companies in the EU would be a good source. Though the players were from different countries, volume from the countries they were operating within was included for market homogeneity reasons.

If the characteristics of an industry sector are high economies of scale, the high cost of entry can indicate market concentration. However, lower economies of scale may facilitate lower market concentrations, because the sunken cost to entry is lower. Determining economies of scale can be accomplished by calculating the capital cost to labor ratio. The capital cost includes the capital required to acquire the fundamental tangible elements and cost coverage to operate an RU, professional fees required to establish the enterprises and all other related costs but excluding labor. That means rolling stock, fixed costs, such as administrative infrastructure (SG&A) [20]. Excluding labor, these costs can be considered "sunken costs".

Incumbents are advantaged in these calculations, because they have inherited rosters for locomotives and wagons, along with maintenance facilities, other support, such as training and pre-existing relationships with the regulators and network IM's. New entrants, however, have no such advantage, but can ameliorate the sunken costs by leasing equipment and subcontracting rolling stock maintenance and hiring operating personnel from specialized employment enterprises specializing in the rail sector. The formula for economies of scale is:

$$R = \frac{C}{L}$$

Where:
C = Capital cost (defined above)
L = Labor cost (defined above)

[20] SG&A is commonly defined as ***"Sales, General and Administrative"***, as fixed and/or sunken costs.

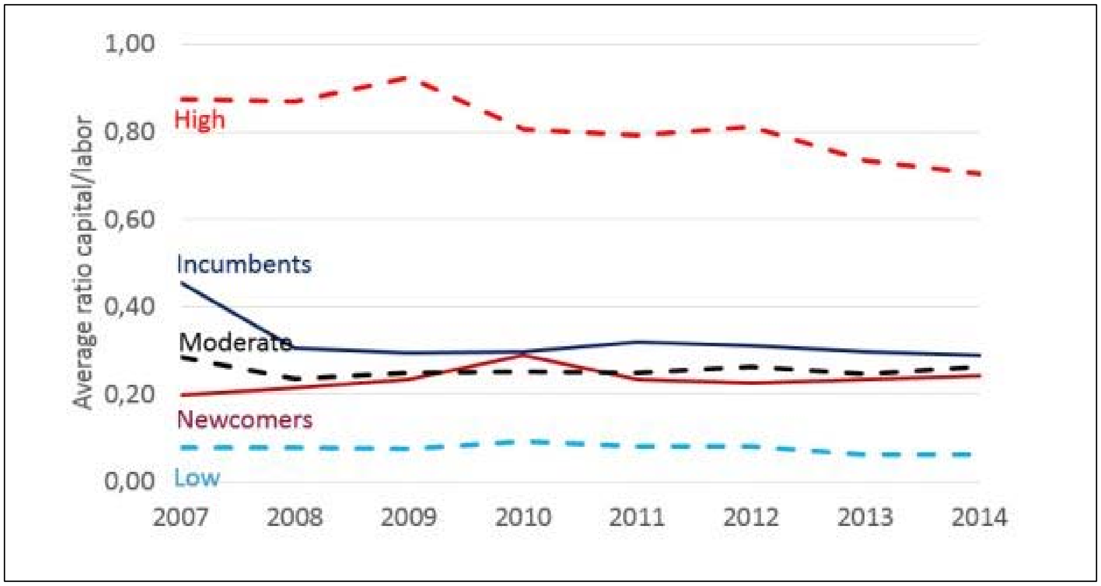

Figure 3: Avg Ratio Capital Cost over Labor Cost
Source: Laroche et al., 2017

R > 0 indicates some level of economy of scale and R = 0 means there is no economy of scale. Figure 3 shows that incumbents and larger firms have an R with a larger value. The significance of these calculations is that an industry sector populated with firms having high economies of scale may be an indicator of high barriers to entry and low competition. In that case, a new RU entrant may want to reconsider entry into that market geography.

Associated with the economy of scale calculation is assessing market concentration. Two metrics are used to determine market concentration.

1. The market share in firm concentration ratio, which, for example, calculates the market share of the top 4 companies in a market (national). When CR4>25%, loose oligopoly exists, CR4>60% tight oligopoly with risk of overconcentration and collusion.

2. The Herfindahl-Hirschmann index (HHI), which helps identify whether an oligopoly or monopoly exists in a market. The HHI is the sum each firm's market share squared X 10,000. High concentration is detected when HHI > 1800 and low concentration is when HHI < 1000.

The intention of this section is to summarize some of the analysis tools that can be used to determine whether an RU should enter a market geography or not. There are more intricacies to these analysis tools that are beyond the scope of this dissertation, but nonetheless, are included for a more complete perspective of recognizing some of the barriers non-incumbent RUs face to enter the market.

2.4 Analysis - Commercial Prospects and Practical Application

In this section, the following research and literature offers pragmatic "on-the-ground" assessments of what is required to implement a successful rail cargo or intermodal service over a corridor.

Consistent with identifying obstacles that prevent financial viability and strategies to overcome those problems, the **CREAM Project (2007)**, presents an overview of the commercial prospects for rail cargo traffic from western to southeastern Europe and extending into the Balkans, Greece and Turkey.

In this approach, the authors state upfront that the prospects for success in shifting cargo to rail must also be measured by what is possible today, in terms of existing infrastructure and routing. In the case of the CREAM project, the analysis focused on aspects of a defined corridor that were specifically non-political.

To accomplish this, an overall management system was established and an inventory of the problems along a candidate corridor was compiled. Once that preliminary work was complete, template solution sets were developed to address those problems. From a long, seemingly insolvable list of problems in operating from Turkey, through the Balkans and to Western Europe, solutions and operational typologies were developed, specifically addressing local conditions along the corridor.

The biggest single issue, other than mechanical and railway system-related interoperability problems (considerable, as well), were delays to the movement of the trains due to elongated and burdensome administrative procedures, related to customs and information transfer. The problems here were solved by conducting normal cross-border administrative duties at natural division, operations and maintenance points, rather than wasting time performing these tasks at locations unrelated to rail operations, locations that were established more for reasons of convenience to administrative personnel, at border points, than necessity.

In this way, customs and border administration duties were now to be conducted simultaneously at one agreed upon location, simultaneously, while other operations-related tasks were completed, such as crew changes, locomotive servicing or replacement, any shunting of wagons in or out of trains and pre-departure brake tests. In that way, train delays and time consumed at border points were minimized and tasks over the entire operational spectrum were streamlined. These operational methodology templates were incorporated over the entire management system and duplicated over the route system.

The tangible result was that to support expeditious and smooth border crossings, the software systems and optimized operational procedures facilitated efficient hand-offs, exchange of documents needed for cross-border operations and the overall streamlining of border crossings.

Ultimately, the focus was on service quality to attract transport demand decision makers, such as forwarders and to that end, the framework of a management system was developed to accomplish that objective. There were standardized procedures and lines of communication established to ensure that all in the transport delivery chain were informed of all data elements needed for expeditious movement of the trains.

With respect to developing traffic volume and scale, the *"String of Pearls"*[21] network concept was advanced. This consisted of strings, which were a combination of existing long distance and shuttle trains on established corridors. Along the way, various consolidation points, in the form of gateways or hub terminals facilitated blending of traffic. The strings linked these nodes along the (route) strings, which were optimized for intermodal services, with respect to infrastructure. As an example, a system was devised for transferring loading units, such as truck trailers and swap bodies not strong enough for handling by cranes.

The idea was to provide the stakeholders, operators and customers with a way to amplify their established networks and expand cooperation with regional partners and to build scale. This concept was also implemented in conjunction with services involving short sea shipping and rail between Turkey and Western Europe, as well as extension of service to the Middle East and Central Turkey.

The **FLAVIA Report (2007)**, an acronym for a pre-feasibility study (with the uncomplicated formal name: **F** reight and **L** ogistics **A** dvancement in Central/South-East Europe – **V** alidation of trade and transport processes, **I** mplementation of improvement actions, **A** pplications of co-coordinated structures), provided a similar perspective. The report is a collection of work packages, comprising a pre-feasibility study of developing intermodal rail service between the intermodal terminal in Wels, Austria and the Port of Costanza in Romania.

This research examined this route, infrastructure, administrative and service quality attributes discussed in the CREAM Project (and other studies, as well), in assessing prospective rail service over this corridor. However, the FLAVIA Report is differentiated by a more detailed analysis of

[21] A description of a network of open intermodal services. ***"Within CREAM, the new concept that is based on the hub-and-spoke or gateway approach, is also referred to as "String of Pearls" concept. This concept aims at connecting the Southeastern part of Europe with the established intermodal production systems in Western Europe."***, Final Report – The CREAM Project, Page 28, with additional references Pages 82 and 104.

the trade flows between the countries, breaking down by specific categories of goods and identifies the products most likely for transport by rail in each direction.

The FLAVIA Report analyzed the operational cost structure with generally universal and common cost elements, recognized in similar research. Practical operational implementation of the service, combined with traffic volume data helped assess the prospects of target market development in the territories analyzed.

Qualitative service elements necessary for the prospective service to be accepted by the shipping community included eliminating the requirement that entire trains or blocks were necessary, as was traditionally the case with other rail services. Another aspect of the offered service was that the frequent departures being planned allowed logistics providers, shippers and direct customers with the consistency needed for their respective internal planning and production processes.

The insights provided by the various participating companies, industry experts and terminal operating companies in Romania contributed to the realistic solutions to both problems unique to the territory, as well as common issues experienced by others operating in territories not covered by this research.

Network accessibility from other countries was also considered as contributing to financial performance and to developing scale. This was accomplished through connections to the proposed service through various terminals and hubs along the corridor.

2.5 Infrastructure and Economics

The work conducted in **REORIENT (2007)**, used a different approach, but with some similarities to the other studies. This extensive research was undertaken, as the **CREAM Project (2007)** endeavored, to assess the possibilities of an integrated, international trans-European railway cargo network, operating both within and through the central and eastern portion of the EU, with the possibilities of spanning all the way through the Balkans and Greece, even possibly connecting eventually with Turkey. In this case, the route differed, in that a prospective transport route, called the REORIENT corridor was studied, originating from the Nordic countries of Norway, Sweden and Finland, through Germany and Poland (through the ports of Lubeck, Szczecin, Gdansk/Gdynia and Świnoujście), and through Czech Republic, Slovakia, Austria, Romania, Bulgaria, Serbia, Macedonia and ultimately, Greece. The corridor focuses of the CREAM Project were shifted within the European side (vs. the Balkan and Asia Minor side), from Western Europe to routes between Poland and the Scandinavian region.

For this dissertation, the incorporation of much of the route structure suggested was reviewed, but with changes noted later in this PhD research, along with the rationale for the route amendments.

Nevertheless, this study was useful in pointing out where there were pitfalls in conducting operations along the suggested routes. The context was to assess the commercial prospects of new, private railway enterprises ("RUs") participating in the newly liberalized and fragmented marketplace, given the perceived disadvantages of using rail cargo by shippers and/or their representatives, such as logistics companies, which closely correlates to the research question posed in Chapter One.

In the **REORIENT (2007)** study, as similarly noted in the Dablanc (2008) research, this work covered not only the technical, financial and operational aspects of such an operation, but offered useful perspectives on the political realities, with respect to institutional barriers imposed by national governments, cooperating with the former incumbent state railways and/or not well separated infrastructure authorities.

In this study, qualitative factors were measured in the form of an extensive revealed preference survey of shippers conducted by the Norwegian Institute of Transport Economics. Quantitative cargo flow research was collected and served as input into several models. These models first simulated realistic operational performance scenarios and their respective costs, given various cargo categories, time (performance requirements) and shipment sizes, along with a comparison of the same shipments going either solely by rail, truck or combination of modes, including ferries from Sweden to Poland and reverse. Given an assumed level of performance quality and cost economics, the next step was to assess the probability of shippers selecting rail, given a set of necessary performance and cost parameters, derived prior. While analyzing the results of the revealed preference survey conducted in this research is beyond the scope of this dissertation, it, nevertheless, offers helpful perspective in viewing the entire picture.

The **Diomis Report (2007)** goes further and analyzed service elements to consider in detail, so that the prospective intermodal service would be attractive to shippers and freight forwarders.

According to **DIOMIS**, to offer a successful intermodal (CT – combined transport), continental logistics service, the following elements must be offered:

- Buffer time for cutoff time for trucks into the terminals. One must be flexible and allow later cutoff times, such as 1800 hrs., to give time for trucks to be loaded and transit to the terminal from being loaded at the customer's dock.

- Early arrival times at the destination terminal are important, so that final mile deliveries can be made in a timely fashion.
- Trailers or containers which have a round-trip booking should be handled / loaded on a preferential, high-priority basis, since they must be delivered quickly to the destination customer and be picked up (or the driver waits for them to be repositioned and/or reloaded) and returned to the terminal for loading on the return trip before the cutoff time. (Fast lane service)
- 95% or better on-time rate
- Consistency in service
- Cost effectiveness

Container hinterland services to/from port areas need to offer:

- High frequency departures from the ports to the inland terminals
- Good management IT tracking for “port-to-door”
- Upside capacity margin for additional rail and truck traffic
- Cost effectiveness
- Inexpensive empty container storage and deployment

In each of the scenarios reviewed by this literature, the common market obstacles identified are distilled down to price, security, electrification and the commercial offer - Unique Selling Proposition (USP).

The first consideration in determining the value of a service should be from the perspective of the customer, the shipper. Prodigious revealed and stated preference research indicates that the primary decision drivers in modal choice are price, closely followed by meeting on-time delivery requirements. However, for those shippers who have adopted the "just-in-time (JIT)" model, the priorities change to frequency of service and flexibility. For those shippers in that category, flexibility translates to reliability and internal convenience of using a service, as due to the risk of thin inventory levels, shippers must be able to react quickly to disruptions. In the end, for either shipper categories, time is most important after price. [22]

With respect to price, the reality to reckon with is the challenge of competitive pricing strategies. Rail suffers a perception, as well as the reality, of disutility, for many reasons recognized in this research, such as network congestion, leading to delays and unreliability, accessing competitive rail paths in a timely manner to allow effective marketing to logistics channels and coordinating the high number of actors within the transport chain to allow a competitive intermodal transport alternative for shippers. This leads transport decision makers to ensure there are alternative options in place, usually excluding intramodality, particularly involving rail. This means that rail transport, at the outset and from a pricing strategy perspective, is handicapped, due to decision makers' perceptions of low service quality.

The research of **CREAM (2007)**, **FLAVIA (2007)**, **REORIENT (2007)** and **DIOMIS (2007)** were all study projects to identify ways to promote intermodal cargo transport, survey best practices, identify cooperation frameworks and methods to streamline and optimize administrative processes that are barriers to efficient cargo flow. Each of the respective projects were organized into work packages that included management methods, communications, optimizing logistics chains, assessing current and potential future capacity issues and finally, extending the transport corridors to countries bordering the Black Sea, as well as countries in Eastern Europe, Caucasus and Central Asia regions, also known by the acronym TRACECA. In the case of the REORIENT Study, the corridor focus shifted to linking Scandinavia, Eastern Europe and South-eastern Europe, the Balkans, Greece and Turkey vs. linking from Western Europe.

Nevertheless, the basic principals in common were objectives included in the work packages, in the form of numerous pre-feasibility studies, whose results have been useful in getting a clear picture of what would be involved in establishing intermodal transport involving rail.

Using essentially the same elements identified to establish cargo rail service, **CREAM (2007)**, **FLAVIA (2007)**, **REORIENT (2007)** and **DIOMIS (2007)** each offered an operational solution framework of process methodologies, each uniquely adapted to their respective studied territories.

A table summarizing the core elements of these studies can be found in **Appendix A**.

[22] **Source:** Floden, Jonas, 2007, ***"Modelling Intermodal Freight Transport. The Potential of Combined Transport in Sweden"***, page 188

2.6 Macroeconomics and Business Models

Shifting from the previous section's pragmatic "on-the-ground" assessments of what is required to implement a successful rail cargo or intermodal service over a corridor, an overview of success factors from a macroeconomic perspective is necessary. It is helpful to "zoom out" for an overview of the marketplace and competition that would define the variations of railway operator typologies and their factors for success.

Examining regional and local economies for the presence and robustness of sectors requiring transport services, **DIOMIS (2007)** published by the UIC considers several macroeconomic factors.

Fundamentals, such as GDP and growth rates are important, as they contribute to both consumer demand and extending the industrial product base. According to **DIOMIS (2007)**, it follows that GDP and growth rates contribute to consumer demand and extending the industrial product base. In the case of intermodal rail freight potential, it is useful to look more at the distribution (concentration) of GDP growth, rather than a general figure. That will help indicate where the markets are concentrated.

The manufacturing sector's share of GDP, relevant because of future growth of industries requiring cargo transportation through the inputs of raw materials (supplies), with the outputs and distribution of the resulting commodities produced from those inbound raw materials helps determine the long term of the rail cargo sector in the region. The industrial base then expands, leading to the exports and imports of inputs/outputs, supporting the traffic density of railway network.

In theory and in most cases, these are operative variables. But this was not the case in Belgium, during which from the period spanning 1990 to 2015 (except between 2003 – 2009), ton/km by rail actually decreased by 13%. Between the period in question, Belgian GDP steadily increased, even during the economic crisis of 2008 – 2009 and further, although industrial production dipped during that time. [23] Paradoxically, this was despite rail transport demand resulting from international traffic generated to and from the EU market through ports. (Laroche 2017)

[23] Laroche et al., ***"Brain-Trains – D-5.4 – Scenario 3 – Regulatory Analysis"***, TPR (UA) P. 6: *"…highlights the slow but continued increase of the Belgian GPP in spite of the economic crisis in 2009 (+22%). It cannot explain the stagnation of the rail freight demand during the period (2.8%). The second comment concerns the correlation between the industrial production and the rail freight market except between 2007 and 2008, where the Belgian production continues to increase and the rail freight market starts to decrease."*

Another variation of this is to examine "near-shoring", that is, establishing sites where intermediate stages of manufacturing and processing take place, from western European countries.

According to **BRAIN-TRAINS (2015),** shifts in production to lower cost countries in Eastern Europe mean that while many inputs go to those regions, distribution and warehousing remain regionally and locally based. That means output traffic moves from the production regions to the consumption regions, especially those with higher per capita income. For this PhD research, this is an important element for assessing prospective corridors for shift potential to rail.

In examining corridors through regions, the report makes the point that while population growth (or decline), is a factor, more important is the distribution of the population. Population density is one of the drivers of demand, critical mass and, therefore, operational and market economies of scale.

In general, GDP growth forecasts portend increased transport volume between the two regions.

However, **DIOMIS (2007)** also discussed the concept of "growth poles". If the distance between "growth poles" is short, then traffic by rail is unlikely to develop. Rather, it will continue by truck.

This is important, because while a country may be wealthy, it could well be because of a robust service sector, which does not contribute much to transportation-intensive industries. Therefore, if economic growth is driven by the service sector, then rail participation in the transport sector is unlikely to grow quickly, if at all. If that is the case, then rail will have a difficult business case for survival. Indeed, in some European countries, such as France, Germany, Belgium and Portugal, the service sectors eclipse the industrial sectors.[24]

Assuming the area qualifies, per above, then we can go to the next step.

If there is an achievable scale of traffic flow, both in and out of a country or region, is that traffic flow balanced, e.g., is there cargo in both directions? And, if there is a balanced traffic flow, is the country or hub even a natural hub for transport?

Part of the **DIOMIS (2007)** research analysis takes into account the anticipated capacity of a system, given growth projections. How many terminals are currently operating in a country?

[24] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), Page 314, paragraph4

Can they handle the traffic now? If not, what would it take to get the capacity up? What terminal expansions are planned? Are there new terminals being built? When?

To determine if a country or region can even handle the anticipated traffic levels, one must know the present infrastructure capacity, level of utilization and whether more infrastructure will be needed.

From a more micro level, looking at the present infrastructure, calculations need to be made.

In **DIOMIS Report (2007)**, this calculation comes about in the form of TEU, with a ratio converting to the term "lifting units" (LU), which comprise the individual objects that the terminal's infrastructure (cranes) can lift from or to flat cars / trucks. The operating assumption is that land-based, not maritime or inland waterway traffic is being measured, as the composition of containers (LU) can be different.

The first question is what kind of industrial sector is the continental traffic serving? If it is chemical, then 20 ft. and 30 ft. containers or swap bodies are often used, resulting in a ratio of 1 – 1.5 LU per TEU. For dry or bulk cargo, generally 40 ft. containers are used, resulting in a ratio of 2.0 LU per TEU. However, for semi-trailers, LUs translate to about 2.3 per TEU. From there, we can look at projected traffic levels in TEU and compare them to the LU units and capacity required to determine the anticipated capacity required for the terminal.

There are also service elements to consider, so that the prospective intermodal service is attractive to shippers and freight forwarders.

2.7 Costing Economics and Costing Models

This section introduces basic underlying approaches to costing and a non-exhaustive review of costing models researched and techniques implemented. Not all of the costing models reviewed are specifically applicable to answering the research question, nevertheless, including the models is helpful for their depth of analysis, overall perspective and overview of approaches.

2.7.1 Costing Economics Approaches

The Ph.D. research work of **Grimes (2004)** highlights one of the principal differences between the railway business models in North America and most of the world, in that private infrastructure maintenance is assumed by the railway owner and/or operator.

Grimes' principal thesis that North American freight railroads are underpricing their transportation and other services because they do not properly calculate infrastructure capital expenditures, resulting in underestimating the incremental nature of capital expenditures and therefore, have suboptimal returns on invested capital, which in turn, does not allow maximizing net income and free cash flow. This is particularly true with variable capital investment into infrastructure.

Furthermore, Grimes' work recognizes that while North American railways are relatively unburdened, with respect to network access constraints, such as timing, capacity and costs, they are burdened with the conundrum of optimal maintenance formulae, considering the vagaries of present vs. future traffic demand.

The North American railways, according to Grimes, are faced with the choices of overinvesting in their infrastructure, leading to poor return on invested capital and suboptimal allocation of capital. Or, Grimes points out, there is the risk of undercapitalization, leading to higher labor costs, increased network congestion, slower transit times, leading to lower quality service and even safety issues, due to slower operating speed, network congestion and reduced line capacity. The consequences of underinvestment in railway infrastructure can lead to poorer service quality, reduced market share and increased liability for safety.

Costing from the non-North American model is discussed in a research paper by Tawfik, Mostert & Limbourg (2015), which offers the more macroeconomic and theoretical view in pricing, especially with respect to the vagaries of external costs. The perspective offered involves determining the appropriate assessment mechanism for imposing external costs on modes of transport, possibly also including rail. [25]

In this section of the paper, titled **"BRAIN TRAINS – SWOT Analysis",** the authors distinguish between operational, external and full costs of conducting transportation. According to the authors, when there are small PPH distances involved in transport, intermodal transport becomes more competitive, when external costs are internalized, with respect to distances. When there are longer PPH distances involved, the opposite is true, leading to a longer distance needed to achieve breakeven costs.

With respect to accounting for external costs, two types are considered: marginal and average costs. The difference between the two is that marginal costs are determined by a bottom-up method, while average costs are calculated through a "top-down" approach. The latter approach is less precise than the "bottom-up" method and, in particular, does not take into

[25] Christine Tawfik, Martine Mostert & Sabine Limbourg, ***"DELIVERABLE 1.1 - 1.2 B: What is the role of costs in transportation mode competitiveness?"*** (2015), QuantOM – University of Liege, Pages 18 – 25

account varying local conditions or circumstances. It is more appropriately applied to a country or industry sector.

Moreover, due to the widely varying range of results obtained from the study's analysis, the average approach may not be the most optimal application of external costs, rather, considering the actual marginal costs or usage of the external asset *itself* impacted, would be a more accurate method to assess that category of costs.

In the "bottom-up" approach, the external effects of how a unique element affects the environment are considered and calculated.

However, with both approaches, the external costs can be difficult to quantify and to monetize, as there are no markets where values can be applied. To start, assigning values to qualitative factors implies a value to a perception, rather than actual tangible damage to a physical asset. Perceptions are subjective and prone to widely varying interpretation and valuation, depending on an individual's opinion of the effect. Add to that, the additional dimension of time, which will have different effects on different externalities, also dependent on both physical degradation of an asset and broad, subjective judgment, as to the longer-term effects.

Given that there is no "marketplace" where established values can be applied to externalities, the authors offer three methods to assess value:

1. The avoidable cost method, in which costs are calculated for a different use or implementing a different transport practice alternative to avoid the externality(s)

2. The opportunity cost method (often called "willingness to pay" method), in which a value is assigned to the externality(s), and then paid to an "economic agent" for the presumed pain, suffering and loss experienced using the resource(s) generating the externality(s) by those conducting transportation.

3. The "damage" cost method, in which damages are calculated for the externality(s) impact generated by the practice of conducting transportation.

All these methods have obvious defects, in that valuation and effect are very difficult to assess, as well as the large ranges and respective scopes of the externalities. In all cases, political debate will surely ensue, as well as increased costs, leading to the questions of intermodal competitiveness.

For this Ph.D., it is important to understand the thinking and underlying philosophies of thought, with respect to regulations, taxation and the government's economic view of rail. For researchers investigating the competitiveness of rail, these views should be acknowledged.

2.7.2 Costing Models

Not all the costing models reviewed were specifically applicable to answering the research question, nevertheless, including the models was helpful for overall perspective, overview of approaches and depth of analysis.

From the wide spectrum of models researched in determining their suitability for this Ph.D., the following filters applied.

1. The model needed to be from the perspective of the practitioner, the RU operator.
2. The structure of the model needed to include provisions for making individual adjustments to relevant parameters.
3. The model should incorporate homogeneity in the context of including different types rolling stock, locomotives and wagons.
4. The model should be a useful tool for RUs to identify parameters that have the most effect on profitability.
5. The model should give insights to investors and financial institutions to determine investment quality.

From the literature, two general categories of transport costing models were researched.

a. Costing models that were specifically applicable to the rail sector
b. Costing models that were applicable to other modes, specifically IWT

Both categories of models had useful points and analysis methodologies, parts of which could be applicable to developing a model for the rail sector.

To frame all in context, the next section further describes other potentially useful cost model candidates, but were not selected for the reasons further described. The following are details on some costing models researched for rail, followed by non-rail transport costing models.

2.7.3 Rail Freight Transport Cost Models

2.7.3.1 Great Britain Freight Model - GBFM (2008)

GBFM was developed in 2008 by the UK Department for Transport to model heavy goods vehicle (HGV) transport flows within Great Britain and between EU trading partners, with a focus on cross-channel traffic.

According to MDS Transmodal, the developer of the documentation of GBFM, the model targets *"average-to-long distance shipments"* for all modes. Of note is that the model uses three geographical levels, which are NUTS2 and NUTS3 for international O/D pairs, NUTS3 for domestic multimodal, as well as 2700 postal code territories for domestic road traffic. An O/D matrix was extracted from available datasets, such as UK trade statistics, the *"Continuing Survey of Road Goods Traffic"* and the rail freight flows provided by the UK's Network Rail.

Trip generation can be forecasted using trend data. Trend data can be simulated by adding developing changes in trip lengths of specific targeted commodities. By combining network and freight service characteristics, the model can also generate multi-modal paths.

It is capable of generating simulated freight rates, based on selected trip nodes constituting a route between O/D pairs. It will also add costs to the simulated freight rates, based on the calculated utility generated of time and reliability, either positive or negative.

This model is of particular interest in this research, because the current model developed for this dissertation uses the same geographic attributes and did survey freight flows on the basis of commodities. The GBFM approach is attractive, because this model is among the most relevant surveyed in this research, as it considers the nature of the freight transport market with the most relevant variables, combined with more traffic data that is geographically more granular.

2.7.3.2 Heuristics Intermodal Transport (HIT) Model (2007)

This model measures both truck and rail costs, individually, through selection of a modal choice, or together, as in combined transport. It is applied to a specific service route and does not allow for a change in route. It is very comprehensive, measuring the costs, given modal choice, schedule times, position of loading units within the train, type and number of trucks, as well as socio-economic costs and environmental effects, with respect to energy, emissions and some form of quantified environmental impact costs. This model compares road only mode vs. CT transport with rail. It was developed by Jonas Floden in 2007 at the University of Gothenburg School of Business, Economics and Law. Because the model measures financial performance, given differing variables, such increased network costs due to infrastructure investments, tax rates, the effects of regulations on financial performance, it could be useful, although it is applicable specifically to the Swedish Railway system and further study would have to determine how it could be applicable to the case scenarios depicted in this Ph.D. research.

2.7.3.3 Jensen Cost Model for Combined Transport (1990)

The objective of developing this model was to determine incremental costs for combined transport (CT) operating on Sweden's railway network. The model is applied to a network of nodes over the network for CT operations. Because the route measure is fixed, it is rather inflexible and cannot measure rail service that differs from CT operations, such as manifest freight trains (trains that make stops with non-CT conventional equipment along a route, known as "liner" trains), in Europe. The Jensen cost model does calculate socio-economic costs.

This model is not applicable to this research for the above reasons stated.

2.7.3.4 Nelldal Cost Model (1980)

The model was developed in 1980, as part of Bo-Lennart Nelldal's Ph.D. dissertation at the Royal Institute of Technology in Sweden.

This model was aimed at calculating costs for either wagonload or trainload scenarios, but not intermodal, likely because at the time, combined transport had not yet become a common practice. This model was more macro in approach, as the "top-down" approach to accounting was adopted, resulting in allocation of costs, rather than on the direct basis of actual cost. Further, the model transport costs are expressed through allocations, rather than on operationally specific costs. Similarly, costs for rolling stock are made on the basis of *average* utilization data. For train operations, it calculates costs for one specific run, not multiple runs over a span of time. For this research, the model was not appropriate.

2.7.3.5 RECORDIT Project - Cost Model for Intermodal Transport (2001)

This model that was developed as a product of a broader work within the research work ***"Real Cost Reduction of Door-to-Door Intermodal Transport" (RECORDIT)***, which itself, was part of the larger research project known as the ***"Final Report: Actions to Promote Intermodal Transport"***. The purpose of this report was to support a revision to a White Paper of the EC to revise ***"Common Transport Policy"***, and in this case, to specifically focus on intermodal transport.

From this work came the development of a software application called ***"Decision Support System (DSS)"***, which interactively allowed a researcher to assess costs of three freight transport routes by road or intermodal rail.

Three corridors were analyzed for this model:

1. The "freight freeway" between Patras - Brindisi - Milano - Munich - Hamburg and Gothenburg
2. The tri-modal transport chain between Genova - Basel - Rotterdam and Manchester
3. The door-to-door intermodal chain along the corridor Barcelona - Lyon - Torino - Verona - Budapest and Warsaw

The loads considered were a "Class A" container, otherwise defined as a standard 40 ft. ISO container, transported on either an 18-ton truck or a 40-ton articulated truck and trailer, as well as railcars.

In order to develop a cost structure and dataset of costs to analyze the three corridors, the researchers established a common, standardized accounting framework and a reference methodology to generate a dataset of costs needed to assess the state of the road and intermodal transport sector by identifying cost categories on a granular basis and then average them within realistic ranges.

From the reference dataset of costs researched from analyzing the three corridors, the DSS software would extrapolate cost data to apply to other corridors of interest and address one objective for this work, which was to develop a generalized cost structure.

The approach was for the model to primarily *seek cost reduction opportunities* within the now-established fixed and variable cost financial structure of transport enterprises, with the objective of enabling policy makers and regulators to determine the effect certain policies contemplated would have on the competitiveness (and by extension, profitability), of intermodal transport actors. The objective's intention was to identify and enhance profitability and also ensure that the prospective regulations and/or policies would not adversely cause intermodal or the rail mode to lose market share.

Said another way, another motivation of this cost model is to compile a detailed list of cost drivers for linking to policy initiatives and predict how those cost drivers would be affected by any proposed policy or regulation, to not inadvertently handicap rail intermodal movement.

Also included in the RECORDIT project were externalities, such as air pollution, accidents, noise, global warming and, in the case of application to road traffic, delay to other travelers. There was substantial attention dedicated to externalities.

For internal costs, there is good coverage of the cost categories and RECORDIT developed a set of reference data set of costs, both internal and external, to apply to modeling of any specific corridor. The cost variabilities over different corridors are recognized and the RECORDIT, would be, according to its promoters, be well positioned as a starting point for more detailed corridor analysis, with credible, researched upper and lower bounds of values for general cost categories.

In overview, with the objective of the model to establish a common, standardized accounting framework and a reference methodology to assess the state of the road and intermodal transport sector as laudable, the primary objective of cost reduction is on a generalized basis and is not oriented towards generating revenue. The structure and methodology of this research is very thorough. The approach might easily be adapted to other research, as well. However, for this Ph.D., it is not applicable, as it is more macro and generalized in its approach.

2.7.3.6 Activity-Based Rail Freight Costing (2009)

For one model that was oriented towards rail, the dissertation work of Troche (2009) focused on business economics from the RU's perspective. As such, any external costs were not considered. He makes good points noting that traditionally, RU cost data was from accounting structures whose main purpose was to meet regulatory and/or legislative requirements, rather than disaggregated sufficiently to be useful for cost modeling.

Troche's experience with acquiring relevant cost data, much of it proprietary, led him to adopt the activity-based costing model. Troche, like this author, chose the approach to dissect the entire transportation process into discrete activities, the advantages of which include sufficient granularity of the cost structure to identify those costs having the greatest influence on profitability, as well as being able to layer in more cost elements, into the underlying structure, as the production process would grow more complex, through more varied services and commodities. [26]

Troche, as well, used the "bottom-up" approach for accounting and calculating costs, since they were expressed as direct, rather than the cost averaging method used in the "top-down" method of accounting. [27]

Troche, as this author did, cross-checked with Delphi sources for validation of cost data, especially as costing over selected routes could be a nuanced operational situation, adding layers of costs that might not exist over other routes. A good example of this is the hidden cost of changing locomotives at some border crossings or the necessity to use a different route, due to non-electrification of a route segment.

The Troche model is very comprehensive, was more oriented towards different train types and was focused specifically on modeling operations over the Swedish railway network and not over any system outside of Sweden. There were assumptions within the Troche model of costing a train single trip vs. the round trip assumed in this dissertation's model, principally because the

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[26] Troche, G, ***"Activity-Based Freight Costing"***, KUNGLIGA TEKNISKA HÖGSKOLAN (2009), P. 13
[27] Troche, G, ***"Activity-Based Freight Costing"***, KUNGLIGA TEKNISKA HÖGSKOLAN (2009), P. 39

route segments selected by this author were researched and selected on the basis of the highest proportion of return traffic in the reverse direction. In that way, this author's model assumed a paid return cycle, especially given the customers targeted were freight forwarders and trucking companies that had an existing portfolio of traffic in both directions between O/D pairs.

All-in-all, the theory and approach were superior efforts and the principles underlying the development of the cost model were influential and helped validate the decision to shift the orientation of the current model used in this research to that of being activity-based.

2.7.4 Non-Rail Freight Transport Cost Models. IWT

There are numerous cost models for the IWT mode targeted for various industry sector participants, policy makers, regulators and researchers. To ensure relevance to the actual transportation practitioners e.g., owner-operators, it was necessary to filter out those models that were aimed at non-operators in the sector, as the costing approach of those models was based on generalized cost, which is not granular enough to use as a simulation costing model.

Guidance was offered from the literature, as to the correct approach to a cost simulation model. The subsections forward describe model structures that are useful approaches that could be adapted to developing a cost simulation model for rail.

The following models targeted the IWT sector and their unique modal characteristics. The methodology framework was useful and applicable to the rail mode.

2.7.4.1 Structuring and Modelling Decision Making in the Inland Navigation Sector (2011)

A significant contributor to the principles endorsed in paper above is the research work of Beelen, Marjan (2011), who, in her dissertation ***"Structuring and Modeling Decision Making in the Inland Navigation Sector"***, espoused many of the basic tenets covered.

This research considers the viewpoint of the vessel owner and the relevant actors participating in the IWT sector. Governmental and regulatory intervention factors are considered exogenous, and considers the main cost drivers, market structure, utilization of the vessels (also defined as "productivity" and "exploitation" as alternate terminology), and from those cost elements, determine both general annual costs and unique costs of a prospective operation over a specific route. Knowing the cost basis of operating over a route then allows the vessel owner-operator to establish tariffs that are sufficiently remunerative.

With this data, sensitivity analyses can be conducted by varying the input variables to observe the result on profitability, using the present (selected) vessel, determining whether investment is warranted in making improvements and/or renovations with respect to improving the efficiency and productivity of the vessel, purchasing a replacement or even an additional vessel, as well as developing case scenarios of different routes, utilization, cargo types and tariff combinations.

With respect to how the IWT sector is organized, to make the financial commitment to either purchasing or making renovations to an existing vessel, the prerequisite is that a long-term contract would have to be in place to ensure that the debt service would be covered by operations, assuming that vessel operators would not have the financial means to handle such a capital expenditure outright.

However, the sector is highly fragmented and therefore, also covered is the nature of relationships that vessel owners might have with one another, as to what is most mutually beneficial, balanced by the freedom and independence of individual owner-operators, who are entrepreneurial to their core and do not take kindly to imperatives handed down from "on-high". (This cultural factor, by the way, is at the root of the independent trucking sector worldwide and also the North American shortline railroad sector, many of whose participants are fiercely independent).

Some owner-operators may wish to enter into alliances with larger shipping companies and logistics groups, who have access to the actual shippers. Other relationships often involve charterers (brokers), who organize engagement on a spot or long-term basis and often, the first-last mile aspect of the shipments.

Beelen, based on the concepts discussed above, developed a cost model to capture both the general cost and more granular data, along with the sensitivity analyses and case studies, based on the data collected.

2.7.4.2 Developing a Cost Calculation Model for Inland Navigation (2017)

In this paper, four authorities with credentials in the IWT sector, Al Enezy, van Hassel, Sys and Vanelslander, developed a framework for a cost calculation model specifically targeted to ship owners and owner-operators. A literature review was conducted, surveying a spectrum of costing models available to sector participants.

From the literature review, it was clear to the authors that the needs of owner-operators were not adequately addressed. One aspect of the IWT sector sparsely addressed was the heterogeneity of IWT vessel operating, as the operational characteristics and related costs are different across the spectrum of vessel types. By collecting the operational cost data, benchmarks would be established to compare the operational costs of a variety of vessels operating over the same routes, but in different market subsectors, such as bulk tank, dry cargo or containers. The model would be structured in such a way, as to be able to input vessel types, with their characteristic benchmark costs and to compare operational scenarios of with different cargo categories and other variables, further explained.

Most of the models covered in the literature review based their cost estimates on pre-determined average values and several models did not take into account waterway infrastructure, port and other fees, many of which are based on the variables of ship dimensions and capacity and also calculated on a yearly basis. Since many owner-operators are self-employed, some models did not consider the cost of labor as a variable, nor the capital costs of ownership, as many entrepreneur owner-operators either do not know or do not want to divulge value details for strategic reasons.

These observations, along with the imprecise and general aggregation of costs data pointed to the need for a more relevant and owner-operator costing model. The foundational elements could be found through extensive interviews with a broad spectrum of stakeholders in the IWT sector.

The feedback received from interviews with shipowners operating a variety of dry cargo, tanker and push-barge sub-sectors was that a model had to address the operator's specific vessels and business circumstances. This means that a spectrum of common ship classifications and their variations had be accommodated in the costing model. Much of the owner-operator input was cross-checked and perspectives were also sought from other service-related participants in the sector, such IWT shipping associations, capital providers, insurance brokers and infrastructure managers. This allowed infill information of nuances that might not necessarily be forthcoming through an owner-operator interview, alone. The model approach evolved from general costs to more specific costs and technical parameters, guided by direct operator input. Some general costs were used from infrastructure authorities, regarding waterway, lock and other associated infrastructure fees. This led to a restructured cost calculation model based on more granular and individual cost elements, as well as company specific data.

Table 1 consists of data categories established for the prospective cost simulation model.

Cost Simulation Model Main Data Categories for IWT Sector

Category	Source	Notes
Ship Data	User input	
Utilization	User input	Also called "exploitation"
Charter	User input	
Fixed Costs	Generalized	Also could be user input cost data
Variable Costs	User input	Also draws from voyage parameters
Voyage Parameters	User input	Also could be generalized cost data
Cost Calculations	Database	Draws from user input & generalized cost data

Table 1: Cost Simulation Model Main Data Categories for IWT Sector

Source: Self-compiled, based on Enzy et al., Cost Calculation Model, Page 11.

Other than benchmark data, input of many detailed data elements were designed for capture by the input of the user, so as to tailor the output based on the owner-operator's known, specific costs. In this way, the user of the model could ensure anonymity and/or privacy, as well as pose "what-if" scenarios to compare them with each other. Added, as well, were provisions to calculate the externalities related to operations in the IWT sector.

The parameter data of the users are stored in a database for later access to run different scenarios and to accumulate a body of data to establish a range of values to apply to cost elements and further study of the sector.

Table 2, below, was useful to cross-check the approach and structure taken with the cost simulation model and to see if there were opportunities to refine the model.

Input parameter/ cost component	Initial parameters of cost model by Al Enezy et al. (2016)	Input parameters of updated cost model and methodology after feedback from the sector
Ship parameters	Use of average and legally mandatory values for ship, exploitation, and voyage parameters	Use of company-specific values for all input
	Input on the ship supported by a ship classification by Rijkswaterstaat (2011)	Ship classification further divided into different ship classes per waterway class (based on CEMT values)
	Consideration of push-tows with up to nine barges (P)	No consideration of push-tows with more than two barges, sine larger tows serve different markets and do not operate as family businesses (P)
Exploitation parameters	Collection of input related to overtime remuneration	Overtime remuneration not a common practice in the sector
Charter party (C/P) parameters	No consideration of different charter types	Consideration of time and voyage charters, and further specification of cost components to be incurred by the ship owner in a voyage charter agreement (fuel costs, port fees, fairway dues, costs of commissions, handling

			and cleaning costs)
Fixed costs		No collection of user input on fixed costs beforehand, standard calculation based on customizable average values	Collection of user input on fixed costs, including capital, personnel, insurance, repair and maintenance, and other fixed cost components per annum
	Capital cost	Capital cost calculation limited to assumptions from literature	Refined calculation of capital costs, enabling separate calculations for the ship and a new engine or any other new investment in the ship, consideration of any depreciation period between 5 and 25 years
	Labor cost	Standard calculation of personnel cost-based on legal manning requirements and minimum per salaries for the Belgian inland navigation sector	Suggestion of legally mandatory values for crew requirements and minimum salaries month, consideration of personnel hired through an agency, and other cost components such as the cost of food, personnel transport, training, and safety (T) per month
	Insurance cost	A single input field for the average value for the total insurance cost	Multiple input fields on different types of insurance, including hull, protection and indemnity (P&I), loss of use, and guaranteed income
	Cost or repair and maintenance	Consideration of average values for the cost of repair and maintenance	Collection of user input on the total and fixed cost of repair and maintenance, automatic calculation of variable cost
	Other fixed costs	Use of one average value for other fixed costs	Distinction between multiple categories of other fixed costs, collection of annual data on the cost of ship necessities, administration and communication, accounting and banking services, withholding tax, municipal tax,
Voyage parameters/ variable costs		Use of averages and estimations as well as user input to calculate the time of sailing, loading, and unloading	Collection of data on the time of sailing, loading, and unloading as user input, in addition to other data, depending on charter agreement, including the price and consumption of fuel and lubricants, the amount of port fees and fairway dues per trip, and the percentage of commission costs in relation to the freight rate
		No consideration of the actual freight rate per ton of	Collection of data on the freight rate per ton, for a comparison between the cost and price

(P) = Aspects particularly concerning the push-barge sector.

(T) = Aspects particularly concerning the tanker sector.

Table 2: Input Parameters in Initial & Updated Cost Calculation Model-Inland navigation sector

Source: Al Enzy, et al., ***"Own composition (based on literature and interviews with professionals from navigation sector)"***, page 10.

2.7.5 Other RU Analysis Software

While there are certainly analysis tools that have been developed and used by RUs internally, they are unique, proprietary and unlikely to be distributed to anyone outside of the RU's organization.

Each of the Class I railroads have pricing and tools resources available for shippers and customers of the company. A good example of one can be found at:

https://www.bnsf.com/ship-with-bnsf/pricing-and-tools/index.page

This type of tool is intended for the user of the railroad, but the underpinnings are from the railroad's internal analysis software and the tool harvests data for ongoing analysis.

Closer to the cost simulation analysis tool developed in this dissertation is a product known as the **OSCAR** rail costing model. OSCAR is an acronym for **O**perational **S**implified **C**osting **A**nalysis for **R**ailways. It is a product offered by CPCS Transcom Ltd., originally a unit of the Canadian Pacific Railway, operated as a consulting division and based in Canada. Today, they have been spun off and operate independently.

OSCAR was originally developed in cooperation with the World Bank, which funded the project and is being used by approximately 20 railways around the world, principally in Asia and Africa.

The cost categories analyzed by OSCAR are:

1. Direct variable costs, which include operating personnel, energy, network (IM) charges, terminal and yard costs, rolling stock and any infrastructure maintenance, as well as equipment leases
2. Variable operating costs, which are all the above, plus depreciation
3. Total long term variable costs are all the above, plus the cost of capital and interest
4. Total costs are long term variable costs, plus fixed costs (SG&A)

Like the cost simulation analysis tool used in this dissertation, in OSCAR, tariffs are set and given the cost matrices, will result in measured values that indicate profit or loss. Tariffs can be adjusted to determine at what points profits are realized.

Source: http://dictionary.sensagent.com/OSCAR_Railway_Costing/en-en/

2.8 Sector Structure

The OECD discussion paper **Van de Voorde and Vanelslander (2009)** acknowledges that it is important to recognize the changing structure of this sector, so that one can have a clearer overview of the decision "food chain", with respect to how sector structure can affect decisions to use rail and whose interests it would serve.

In overview, these authors offer these main points in this work:

> Horizontal integration, defined here as integration across companies within the same broad industry sector is more likely to be implemented through alliance mechanisms, rather than merging the respective entities.
>
> Vertical integration, defined here as cooperative arrangements between enterprises across their respective spectrum of services, broadly spanning the logistics chain, taking the form of joint ventures and dedicated handling on behalf of the cooperating participants.
>
> Non-transportation sector players are involved principally for short term financial gain vs. the mission of providing long term transportation services and ancillary services offered through the business model of the targeted company. However, these companies are acquired for financial investor portfolios based on generating value as complementary to the portfolio, as a "bolt-on", and also based on risk and return.

The authors outline the forms of cooperation and relationships that form between the various typologies of companies in the sector thus.

2.8.1 Forms of cooperation

2.8.1.1 Private Sector

Shipping companies

- Vessel sharing agreements (VSA's)
- Alliances
- M&A

Stevedores

- JV's
- Dedicated terminals
- Consortiums

- M&A with TOC's
- JVs with TOC's

Hinterland operators

- Shipping companies:
  - Block trains and consolidation
  - M&A

- TOC's
  - JV's

- Other hinterland operators
  - Alliances with other carriers

2.8.1.2 Public Sector

Port authorities

- Shipping companies
  - dedicated terminal concessions
- TOC's
  - Concessions
  - JV's
- Other port authorities
  - Alliances

The main points from this research are that *"Mergers connote anticompetitive market power and its undesirable effects"*, but also that the desirable effects of mergers can be achieved through non-merger (M&A), means, such as alliances, joint ventures, consortiums and shared infrastructure.

In summary, the overview offered from this work helps to frame the business climate and evolving relationships, in the context of surveying appropriate sector typologies to answer the research question.

2.9 Synopsis

This author expects that applying the concepts, observations and refinements advanced in the literature reviewed will lead to a general sense of the range of the most optimum typologies and operational practices for a railway undertaking, not only in Europe or North America, but universally, given that the basic principles for success surveyed here can be applied.

Through all the research and literature reviewed, some gaps were noticeable.

Aside from the primary decision drivers in modal choice are price, closely followed by reliability, often expressed as time. Internal convenience of using a service is an often-overlooked aspect of rail service, in particular, wagonload traffic. Another key figure to consider is the potential rail customer's shipment origin and destination, for if both are not served by rail, of what value is the rail service?

This means that very local infrastructure, not considering intermodal terminal areas and seaports, often determines whether a customer will opt for truck or intermodal rail. A good example of this is the presence of a railway siding, either directly serving a customer or at least a designated railway track loading area within an industrial zone or area of distribution centers.

Other than intermodal traffic, which would use dedicated terminals for those types of loading units (containers and trailers), if there is no provision for loading or unloading single or multiple wagonloads of any cargo that would normally be carried in truck trailers and containers, (or, for that matter, any commodity), then rail will seldom be used.

With intermodal traffic, there is some probability that with a combination of good rates and service, a shipper could be persuaded to use rail for intermodal traffic. However, if a shipper had access to a conveniently situated railway siding within the local industrial district or even more optimum, a siding directly serving their industry, shippers would likely be persuaded by more competitive rates, since there would be minimal or no PPH costs, at least to/from one origin or destination node.

For completeness of the how to make the rail mode attractive to shippers, the ability for railways to provide single wagonload service is needed. An RU would want to know what financial structure or public sector assistance would facilitate building or renovating sidings and local railyards. There is nothing in the literature addressing this very foundational factor.[28] It is foundational in the sense that this is how almost all railways started from their roots, with the

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[28] In general, this gap exists, with the exception found in this source: Dablanc, Laeticia,**"*Quel fret ferroviarire local - Réalités françaises, éclairages allemands*"**, Pages 199, 200, 208 and 209, which covers subsidy possibilities.

logistical convenience and efficiency of large volumes of cargo transported in a large loading unit, aka the railway wagon. Though wagonload traffic is not targeted in this Ph.D., primarily because sidings and small rail yards are no longer generally available and if they existed with some density, then wagonload volume would be included in the traffic base.

The second of these gaps involves economic development campaigns and programs, as a matter of policy. Universally, these are initiated by both the public and private sector, with the objective of creating economic clusters. Coordinated economic development efforts locally and regionally lead to the formation of economic clusters, which in turn contribute to density and scale. This relevant topic is addressed within this dissertation under the term "economic clusters" and can be found in beginning with ***Table 4: Desired Corridor and O/D Pair Attributes Checklist – EU***, Section 4.14.2 – Optimal Operational Scenarios, which finds its way into selection criteria checklists, such as **Table 5: Flow Chart Checklist Matrix.** The role of economic clusters is addressed in **Section 4.8.3.** Economic clusters as criteria can be found in ***Sections 5.2.6 Summary of the Rationale for Selected Matrices of OD Pairs***, ***5.2.7 Matrix of Relative Strengths and Weaknesses of O/D Pairs*** and throughout **Section 5.3** as qualifiers for O/D pairs for future candidates for analysis as case scenarios, in the context of adherence to selection criteria. **Section 5.7 Summary and Initial Conclusions of Cost Simulation Model** completes coverage of this topic within this dissertation.

As was noted in the literature, due to apparently non-business oriented political policy directions, as well as institutional inertia, it is difficult for enterprises that have interests in the rail sector to move governments to coordinate the vision of assembling all the assets to create an environment that generates the type of economic activity that fosters rail growth.

The third of these gaps of the literature reviewed, in aggregate and while generally helpful to establish background, overview and identifying problems (and proposed solutions), did not really address how an RU would survive and prosper in the newly liberalized environment of an open access railway network on a more granular basis.

In many industry sectors not currently (nor formerly), government operated, there are numerous "how-to" publications, as to how to succeed with an enterprise in that sector, with plenty of resources in the form of literature, case studies, industry and advocate organizations and promotional alliances to promote and support entrepreneurial efforts to establish and operate a small to medium size railway enterprise. In North America, for example, one early and seminal piece of literature for the "short line railroad" sector is the book ***"Starting a Short Line – A Review of the Fundamentals of Starting a Short Line Railroad"*** by **Larry McCafferty, Jr. and Peter A. Gilbertson**, published in the US in cooperation with the American Short Line

Railroad Association in August 1983. By the time this literature was written, there was a clear understanding and insight into the functioning of the rail freight industry sector in North America and the short line railroad industry sector was in full blossom, catalyzed by the Staggers Act of 1980, which deregulated railways, trucking and aviation in the US.

At the commencement of this Ph.D. and at the time of conducting the literature review, there were no such publications found that would serve as a similar guide to the rail freight market in Europe or indeed, to any newly liberalized open access railway system in the world.

In summary, within the literature reviewed, in addition to the dearth of “how-to” literature, referenced above, there were other gaps noted.

There was some, but generally sparse discussion of policies or business directions to incubate and build complementary business sectors and a concentration of those also related and complementary business enterprises in a region to create the scale necessary to make cargo by rail price and service competitive to trucks.

While the objective of much of the literature was oriented more at identifying costs, interoperability and direct operational conditions that directly affect potential rail cargo service (and, therefore, their inclusion in the literature review to answer the research question), nonetheless, from a policy and long-term economic overview perspective, it is important to also acknowledge economic cluster development as an additional tool.

Chapter 3 – North American Closed Access vs. Open Access Business Models

3.1 Introduction

In this chapter, the differences between the North American closed access and the open access freight railway business models are presented. While the North American railway operators may be burdened by heavier capital expenditure costs because, for the most part, rail operators maintain their own infrastructure, they are not burdened as much as open access rail operators by still heavier regulations, high labor, energy and network access charges, as well as the hidden hand of competitive former incumbent railways, operating through governmental and regulatory proxies. The North American RU operator variations will be discussed in further detail later in this chapter.

The respective networks have different characteristics, in that there are generally (except for Australia and New Zealand), shorter distances between and within most open access countries, hence more line or corridor density, than North America. Weight, dimensions and capacity of railcars also play a role in efficiencies, as does the ability for North American railways to "double-stack" containers, due to less restrictive loading gauge (height, most often due to overhead catenary, bridges and tunnels), and axle weight constraints (due to bridges, rail weight and underlying track structure), compared to many countries. In some cases, track gauge also plays a role, in that railways in some countries operate over track that is less than the standard gauge of 1435 mm, such as 1000 mm ("Meter Gauge") and 1067 mm ("Cape Gauge"). [29]

The cost, revenue and capital structure accounting approaches and practices are compared. These factors are explored in examining the cost structures of North American railways vs. open access railways elsewhere.

To expand upon what was summarized in **Chapter One**, it is first necessary to differentiate between the different freight railway enterprise business models, from the most fundamental forms ("hook and pull" traction), through the spectrum of business model types that developed in adapting to unique territorial market and business conditions. The business models at the

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[29] Nearly 30% of the world's railways are broad gauge, defined as measuring between the inner faces of each rail, 1520-24 mm (Eastern Europe, Baltics and Russian ex-territories), 1600 mm (Ireland), 1668 mm (Portugal and Spain – "Iberian Gauge") and 1676 mm (India, Pakistan, Bangladesh, Sri Lanka, Argentina and Chile). In general, wider gauge was adopted for military reasons to be incompatible to potentially invading armies and in the case of ex-Soviet states and Russia, greater tonnage and dimensional capacity, due to more robust infrastructure and rolling stock dimensions (loading gauge).

end of this typology spectrum would be companies integrated with varying combinations of other transport and logistics subsectors.

3.2 Railway Typologies – Horizontal and Vertical Integration

This research will explore different general typology combinations of North American freight railroads and those elsewhere in the world. Typologies in all geographies have varying degrees of vertical and horizontal integration, with the freight railways of North America more vertically integrated and China and India largely both vertically and horizontally integrated.

Horizontal integration, particularly in the EU, ranges from none (simple traction providers), to holding companies that integrate RUs within a holding company that holds terminal operating companies and/or have strategic partnerships or joint ventures with shipping lines or their subsidiaries.

Some railroad enterprises, such as within North America, are conglomerates with large portfolios of RUs. An example of such a typology is the US conglomerate Genesee & Wyoming, which owns numerous shortlines and regional railways in North America. Genesee & Wyoming now also owns Freightliner, operating in the UK, Germany and Poland, as well, and up until recently, Rotterdam Rail Feeding, a small terminal RU, serving the Rotterdam Port area. They and other enterprises also have complementary terminals, warehousing and distribution arms, locomotive and car repair enterprises and contract shunting operations.

The characteristics of closed access North American and open access RUs differ broadly, in governance, ownership and operational models.

The characteristics of North American railways, in general, are that they have limited cross-border issues, have technical and commercial interoperability. Rolling stock, wagons and locomotives are compliant with North American technical standards and are readily interchangeable with any railway in the general system. Wagons and locomotives are generally privately owned by RUs or leasing companies and some are available for use on an ad-hoc basis by other RUs to satisfy a temporary demand if the RU is unable to supply the correct wagons for the traffic at hand from their own or leased roster of equipment. A long-established system of operating and compensation methods facilitates the use of rolling stock, without separate, long-term formal agreements to supply wagons for traffic, either on a long or short-term basis. For longer term traffic, with commitments by the customer or shipper, the normal practice is for either the shipper or consignee to enter into longer term lease agreements with an equipment leasing company, as they are more cost-effective, and the customer is also assured of a consistent supply of standardized wagons of the optimal type required for the traffic at hand. [30]

Historically, the operational characteristics of North American Class I railways, in general, has been that of building long trains (1 – 2 km in length), in yards to a point where they are large enough to economically justify operations over each individual railway's longer distance corridors between their terminals or interchange points with other Class I carriers. This is also true of railways in Russia (and their former satellites), China, India, Brazil and Australia, with wagon interchange taking place within each country's respective interchange points within their often vertically and horizontally integrated systems.

European freight operations, on the other hand, have had to work under the constraints of competing with passenger train interference for paths, considering power-to-weight ratios, in the context of performance (speed and acceleration), and the length of trains. The length of trains is governed both by performance and length of passing sidings, restricting train length to the shortest siding along the route, as well as any terminal restrictions.

Due to this, while possible, securing ad-hoc train paths in Europe is more difficult and in actual practice, operations take place more on a scheduled, inflexible basis, often operating at night and/or at reduced priority to passenger trains.

Aside from their long distance, trans-continental and regional corridors, the characteristics of North American railways, historically, is that of a dense network of smaller yards, terminals, sidings that facilitate car (wagon) load and small block train operations, a legacy of their earlier role in the development of the continent. However, the larger regional and Class I railroads, in general, actively discourage acquiring that form of traffic, leaving the assembly of wagonload traffic into blocks to the short-lines and terminal railways, commercially operating as the "retailers" of rail transport, which then forward the wagon blocks to the "wholesalers", the Class I railroads. From an operational and marketing perspective, the shortlines and regional railways act as feeders to the trunk lines of the Class I railroads.

Also recently emerging, some Class I railroads, such as CSX Transportation, are eliminating some yards altogether, preferring to focus on dense, line haul between larger terminals only. Whether this is a good long-term strategy remains to be seen, as the principal proponent of this strategy, E. Hunter Harrison, former CEO of CSX, who died in December 2017, was a strong advocate of this strategy component. His vision of "precision scheduled railroading", an

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[30] In North America, privately owned leased wagons represent 86.11% and RUs 13.89% of the total wagon roaster. Source: **U.S. Bureau of Transportation Statistics** (2019).

operating practice known by the acronym "PSR", has its disciples, but also detractors within the company, who currently strongly argue against the methodology (and resist its implementation), as well as a majority of shippers, who have involved the US Surface Transportation Board (STB), in their complaints over deteriorating service and high fees. The merits and demerits of this operational methodology are beyond the scope of this research, but nonetheless, it is relevant to be aware of the business model and the ongoing issues of those operating practices. It should also be noted that as of mid-2018, CSX has reconsidered closing yards (particularly "hump" or gravity yards) and is reopening those on a case-by-case basis. Their experience with the new operational experiment has resulted in some refinement to the yard rationalization initiatives and thus, has abated them somewhat. [31]

There are other dissenting voices against PSR that have emerged. In 2019, Matt Rose, executive chairman of the Burlington Northern Santa Fe (BNSF) said, *"A PSR method that seeks about $US 125m in cost savings from every thousand employees cut isn't thinking long-term, as it often ignores service disruptions to customers. Cutting capex to a lower percentage of revenues, for example, less than 15%, to achieve PSR goals isn't the correct measurement."* Rose further stated that *"BNSF needs to grow units, not just revenue yield. Disengaging from our customers to change internal cost savings is not a good long-term business strategy. De-marketing tactics can result in unanticipated but logical bad public policy outcomes. There's nothing wrong with being a low-cost supplier, but ignoring your customers until you hit a wall on costs can have undesirable longer-term consequences."*

Wagon utilization under the PSR operating practice is also under question, as according to FTR Transportation Intelligence, those figures have remained relatively static. Said Todd Tranausky, the FTR vice-president of rail and intermodal services, *"The historical long-run average for utilization is around 82% and we are in the mid-to-upper 70% range through our forecast period extending through to the end of 2020. The loss of freight has outweighed any sort of efficiency benefits shippers might have received from PSR. There is simply less freight out there that needs cars to move it compared with 2018. Part of that is a response to the weaker truck market, part*

[31] Of late, variations of the "PSR" operating practices have been adopted by all seven Class I North American Railroads, with arguably mixed results. Though the financial and stock market performance of the railroads has been enhanced, to the approval and delight of investors and management, many operational, service delivery, equipment and network utilization, along with employee and customer relations problems have emerged. The crescendo of their collective complaints and dissatisfaction have drawn the attention of the US Surface Transportation Board (STB), the regulatory body governing railroads in the United States. There is active consideration of some form of regulatory action and consequences currently being contemplated by the STB, which is processing the results of two days of hearings conducted in Washington DC on April 26 and 27, 2022. Source: ***"STB Hearing on Urgent Issues in Freight Rail Service"***
https://www.youtube.com/channel/UCgd2FPpKSpQZ57p771aafNg/live and https://www.stb.gov/

of that is a slowing economy, but certainly part of that is also PSR and the changes carriers have made to their networks." [32]

CSX has countered some of the dissent from PSR's detractors by introducing numerous IT innovations to increase operational efficiencies, by tracking railcar movement on a granular basis and spot enroute delays, especially at intermediate yards.

Nevertheless, many customers are still unhappy and have made their views known, of late, by testifying at the hearings conducted by STB, as noted in footnote 29. Mr. Jim Foote, the CEO of CSX also participated in the same hearing event and many were not receptive to his testimony.

Much of the blame on CSX's performance was focused on the decision to lay off far more employees than necessary to still maintain the buffer needed to achieve service levels. Indeed, the core problem today with all Class I railroads in the US, with respect to deteriorating service levels is directly linked to the PSR ethos of doing more with less and the massive furloughing of employees, compounded by the recent pandemic.

At a recent meeting of the Midwest Association of Rail Shippers (MARS), in July 2022, held in Lake Geneva Wisconsin, Foote said, *"If I had the decision to make over again … we would have never laid off an employee"*, Foote said. "*Never. But there was no vision of the future, there was no idea what we expected to encounter."* The layoffs were predicated on the belief that with the expected economic downturn in the economy, demand for rail transport would similarly diminish. When that did not happen and the US economy proved more resilient than expected, CSX and the other Class I railroads were caught short of operating employees and rail service levels and general quality diminished to crisis proportions.

Overlain with the lack of operating employee problem is the ongoing issue of job flexibility, or rather, in the case of the Class I railroads, employee-perceived job inflexibility. The railroads have imposed extremely rigid policies of attendance on their operating employees, resulting in high levels of dissatisfaction, to the point that many simply quit. Foote, at the same conference, said: *"We have an issue with retention. … Half of them, in the first six months, quit, many of them in the early days of when they're actually called to go to work on a regular assignment, or for the first time when they realize they're going to have to work on a weekend or a holiday, or on their kid's birthday. We need to provide employees with greater flexibility,"* he said. *"Is it a different kind of bid arrangement, where they can go work on this kind of job one day, and this kind of job another day — yard jobs, where they can have a regular assignment*

[32] Barrow, Keith, ***"Precision Scheduled Railroading – Evolution or Revolution*"**, International Railway Journal 17 September 2019.

and work regular days off, and then the people that want to make more money can bid the road jobs. We need to understand and we need to communicate and work more with our employees, so we can change what clearly has become a frustrating environment for them. If we're going to be successful … we must have a happy, productive, unionized workforce."[33]

Indeed, job flexibility and lifestyle balance issues are at the core of the grievances motivating a rail strike in the US, which was expected in early December 2022. The US Presidential Emergency Board (PEB), the final arbiter, in the case of an impasse, prevailed with their ruling and forced employees to accept a rail employment contract with disadvantageous conditions, as regards job flexibility issues. As part of the settlement, a back pay provision of up to $11,000 USD per employee will be made in 2023 and a substantial number of employees are anticipated to opt out of the union contract and employment with the railroads and simply quit.

On 26 September 2022, Foote retired and his successor is Joseph R. Hinrichs, "*formerly the President of Ford Motor Company. He also served as President of Global Operations, President of the Americas and President of Asia Pacific and Africa"*.[34]

In North America, inland terminals are being developed with both private and public money, with cooperation from local governmental authorities, who see the economic development implications for their respective territories.

Intermodal transportation has developed vigorously in parts of North America where there is the potential for efficient block trains between major and inland terminals from both river and seaports to consumption regions. This is especially true in the Southeastern part of the US, where numerous distribution and warehousing operations are currently and have been developed by large retailers and institutional investor consortiums. This is due, in part, to the expansion of the Panama Canal, allowing larger, "post-Panamax" ships of 12 – 14,000 TEU capacities to allow all water transport to the SE ports, without trans-loading cost penalty and the expensive cross-country haulage from the West Coast North American ports to destinations east of the Mississippi River, which define the population center point of the US.

With respect to competition, the differences between European railway undertakings (RUs), is very much between the modes, as in truck vs. rail and to a lesser degree, between RUs and their associated logistics partners, if they are participating is some form of integration. In North America, railroads are more interested in retaining traffic moving over their own systems to

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[33] Lassen, David, ***"CSX's Foote: Blaming PSR for rail problems is 'nonsense'",*** Trains Magazine Newswire, 19 July 2022

[34] CSX website: ***https://www.csx.com/index.cfm/about-us/media/press-releases/joseph-r-hinrichs-appointed-president-and-ceo-of-csx/***

maximize revenue, rather than letting another carrier get a greater share, but at the possible consequence of a poorer service offering to the customer. In this way, this practice is shortsighted and takes on cultural nuances that have less to do with business and more about simply raw competition. While enlightened managements recognize this issue and are addressing it, the unspoken policy exists, although it is lessening with the retirement and ongoing attrition of its adherents. [35]

In contrast, within Europe, given the generally shorter route segments, network capacity issues, competition with trucks (which are better suited for the short-to-medium haul traffic), the railways in the EU must look for better opportunities to build scale by focusing on traffic between seaports and inland terminals, consumption regions and production centers, which are often linked to warehousing and distribution clusters. However, the RUs encounter formidable competition from not only trucks, but inland waterways and short sea shipping over longer hauls. Moreover, the remaining options of perhaps building traffic within these economic clusters on a local basis and building wagonload traffic into block trains is often crippled by government and infrastructure network policies that discourage the use of existing terminal and local infrastructure.

In Europe, what few sidings, small yards and terminals continue to physically exist are being or have been eliminated from use through closure by network authorities, who often impose burdensome conditions on their being brought back into active use. Examples of this policy are requirements to completely rebuild a siding or other connecting track, despite their present physical condition being more than adequate for safe, slow speed operations. This policy results in modal shift to truck and lost opportunities to develop rail traffic. This has other implications in the form of inhibiting economic development initiatives that would allow small and medium sized enterprises ("SME's"), to grow to develop enough scale to ship in wagonload quantities vs. only truck/container or less-than-truckload (LTL/LCL) quantities.

However, with the North American railroad system, the dense network of sidings, industrial and terminal railroads, along with the more entrepreneurial Class II and Class III railroads (the regionals and shortlines), contribute as feeders to the Class I mainline railroad systems. While there continues to be increased intermodal and unit train operations in North America, there is still a significant level of traffic in the carload or small wagon block categories.

In North America, properties with a rail siding, a long spur or even a small, dense network of track within a warehousing or industrial complex can increase their value. Indeed, as a matter

[35] Author observed behavior from work experience in working for a US shortline railroad.

of best practice, industrial and commercial "siting" consultancies have emphasized to their clients of the necessity to select sites that allow them expansion options. Sites without rail options are valued less and de-emphasized in the matrix of options presented to their clientele.

Within North America, large economic development firms, such as Trammel Crow Co., Partners Warehouse, Prologis[36], CenterPoint and NAI Hiffman have established large warehousing and distribution centers, some of which have either intermodal and/or loading facilities that have rail access, characteristics considered as desirable.

Property development models that include rail have strong institutional investor backing by pension funds, insurance companies, banks, and various Wall Street funds, all of whom understand the value of rail connections and an internal rail network within their portfolio of warehousing and distribution properties. Rail access takes the form of both intermodal and car/wagonload traffic in the US, as a promising further growth segment.

However, of late, there is a new factor considered by not only industrial property developers, but the large shippers and logistics companies. As discussed earlier, that factor is the adoption of operating practices in North America by the Class I railroads, known as "Precision Scheduled Railroading" (PSR), which has proven unpopular with some logistics decision makers.

Adoption of the PSR operating model by the Class I railroads has led to a flat or diminished overall share in intermodal traffic.[37] Some railroads, such as the BNSF, have offset this somewhat for the future, by establishing inland terminals for container transloading (40 ft. container contents into domestic 53 ft containers), or redistribution of 20 and 40 ft. ISO containers for either further movement by rail or by truck. [38] This initiative is also partly due to congestion issues experienced at the Port of Los Angeles/Long Beach.

In the EU, with car/wagonload traffic, this is not the case, due to shrinking options for supporting local infrastructure and de-emphasis on this form of traffic, due to costs and the generally smaller haulage distances for this type of traffic, as well as the high cost of paths for freight trains, for which RUs seek to optimize their traffic.

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[36] Prologis has shifted to now focus strictly on e-commerce and related types of consumer goods

[37] "Source: Progressive Railroading 22 September 2022, ***Intermodal a drag on U.S. rail traffic in Week 37***, ***"7.3% intermodal volume decreases in the week ending Sept. 17 compared with the same period a year ago, according to Association of American Railroads data."***

[38] Source: Progressive Railroading - 3 October 2022,***"BNSF to build $1.5B rail complex in Southern California"***

3.3 RU Ownership and Infrastructure

In general, the underlying railway infrastructure and supporting land in North America is owned by the RU itself, where in much of the world outside of North America, the infrastructure is owned by public jurisdictions.

In North America, there is a variation of RU infrastructure ownership that exists under certain conditions. During periods of economic downturn in North America, when railways ceased to have a good economic case for continued survival, many railways, from branch lines to entire regional networks became candidates for abandonment. In several US states and within some provinces in Canada, the local, state and regional governments realized that if the railways did not survive, their areas would suffer severe economic consequences, as railways were economic lifelines that kept industry in place. If railway services ceased, the enterprises that needed the service would then relocate to areas that did offer rail service.

As a result, substantial public monies were expended to acquire railway lines to avoid a mass defection of local industry to other locations. This gave rise to the practice of state and local support to maintain and even build new railway infrastructure and to establish processes for operator selection.

This approach to salvage railways that otherwise would have been liquidated for scrap almost immediately paid dividends. While the process of selecting and retaining operators was not always smooth and trouble-free, in general, the policy was successful.

As a result, there is another business model for RUs in North America that involves an enterprise operating the railway only and paying the public sector jurisdiction for the rights to operate on the publicly owned railway line.

This has advantages and disadvantages for both parties. From the public sector perspective, they have more control of railway and operator practices. They impose restrictions and some level of control over an operator and select operators that they believe are long-term players, who can operate commercially competently and who have the skills to operate a railway safely.

From the RU’s perspective, while the public oversight can be burdensome, depending on the local government mentality, in many cases, the operator benefits, because maintenance of the costliest elements of the infrastructure, such as bridges, tunnels and the railway infrastructure itself, are subsidized, in large part, by the States themselves. As an example, an investment analysis study conducted by this author on a railway in New Hampshire found that the State paid 80% of all maintenance and repairs to the infrastructure, the costs of which would otherwise have been impossible for the RU to undertake. In this case, the State had and was in the process of purchasing other abandoned railways in the state, then salvaged track and other materials for re-use by the operators. In this specific case, the State government departments in charge of transportation have management personnel who are experienced professionals and who understand and support local railways.

This is not always the case, where in other states, their departments of transportation are often staffed by untrained administrative personnel, who are not experienced, technically qualified or have the underlying rail-oriented professional philosophy that fully supports rail. In these cases, the operators and the railways in that state suffer and the rail support mission is poorly executed.

Also, it is not unknown to have local politics interfere with the mission of rail support. Whether in North America or in countries with governments with questionable political integrity practices and less than optimal transparency, responsible RUs suffer numerous problems. These problems manifest themselves as unnecessary regulation and targeted "inspections", as well as forcing the RUs into business transactions with favored parties, but under unfavorable business terms. Some RUs have suffered massive theft of material, supplies and expropriation of railway assets, such as rail, land and even entire bridges, to the point of the RU not even being able to continue operating the railway. [39] Exploring this interesting aspect of RU form is not the topic of the research and beyond the scope of this dissertation, however, should be noted. Nevertheless, with respect to another form of business operating model, this hybrid option must also be acknowledged.

3.4 Categories of Railway Undertakings (RU's)

The following is the structure of the railways that are relevant to this research. In this section, we will first define the typology universe of railway undertakings and select those who most correlate with their analog types in each continent in the typology diagram following this section.

3.4.1 North American Railway Undertaking (RU) Types

There are three basic forms of railways in North America and they are defined, as follows:

3.4.1.1 Class I railways

The US Surface Transportation Board (STB) defines a Class I railroad as "having annual carrier operating revenues of $900 million or more, as of June 4, 2021. or more using 2019 dollars as a

[39] Railroad Development Corporation vs. Republic of Guatemala, ICSID Review, Vol. 28, No. 1 (2013), pp. 27–32

baseline for revenue calculations going forward". Source: US Surface Transportation Board (STB)

The closest Class I railroads comparison within the European continent are the incumbent, former State railways.

3.4.1.2 Class II Railways

The US Surface Transportation Board (STB) considers a railway with gross operating revenues greater than $40,400,000 and less than $$504,803,294 for a minimum of the last three years to be classified as a Class II railroad. The Association of American Railroads (AAR) considers a Class II a regional railroad if it operates at least 350 miles (563 km) and earns at least $20 mm in revenue or earned revenue of between $40 mm and the Class I revenue threshold, regardless of line length. In the US and Canada, this mid-sized category of railways is considered "regional railroads" by the AAR. As of 2021, there were 22 Class II railways in the US.

3.4.1.3 Class III Railways

Railways in this category have gross operating revenues of less than $40,400,000 mm annually and are also defined as "short-line" railways. Typically, they function as 'feeder" lines to either the Class I or Class II railways and are often the first and final mile to their customers.

This category of railways is the most interesting and is the most analogous to the operators of the most recent RU's that have emerged in the EU, as a result of railway liberalization.

Many Class III railways were, at one time, either former branches or portions of Class I railways that were either abandoned or sold, because these line segments could not continue to profitably operate under a heavily unionized cost structure, a changing transportation environment not favoring rail transport and were also facing the prospects of heavy capital reinvestment in the infrastructure, because of many years of deferred or non-existent maintenance.

As a result, these line segments were sold to entrepreneurs and local political jurisdictions eager to maintain rail connections for continued economic relevance or to rail salvage operations, which sometimes saw commercial merit in continuing rail service.

In other instances, Class I railways disposed of these portions of railway lines to carefully chosen and trusted enterprises, who were favored to operate the line on behalf of the Class I railway. In the beginning of rail deregulation in the early 1980s, many of these lines were quickly sold outright. As these cast-off lines began demonstrating profitability, now noted by the Class I's, the disposition of the lines then started to take the form of long-term leases, in place of an outright purchase and sale transaction. In this way, Class I railways were assured of continued feeder traffic for their main line operations, but without the disproportionately higher traffic origination and termination costs. The leases of these lines gained favor with the Class I's, especially in the cases of line segments with connections to competing railways. As of 2021, there were 603 US Class III railways.

There is a subcategory that could arguably be included with Class III railways, which are independent shunting operations within yards, terminals and rail line segments within privately owned infrastructure and operated by industries and/or their designated contract operators. From a US and Canadian regulatory perspective, these railway operations would be under the jurisdiction of the US Department of Transportation Federal Railroad Administration (FRA), or the Canadian Transport Ministry, if they interchanged at any point with the "general system of railroads" network of other connecting carriers. If they do have an active connection, these railways are categorized as "non-isolated". If they do not physically connect with any other railroad, they are considered "isolated". In most cases, isolated railroads are not subject to FRA regulation. However, if they were isolated, these carriers would not fall under the jurisdiction of the respective regulatory authorities. In any case, this category of railways will not be included in this dissertation.

3.4.2 Europe and Other Open Access Railways

From the European perspective, the following categories of railways will be relevant.

3.4.2.1 Present and Former State Enterprises (incumbent railways)

These RUs can take two forms.

Using Germany, as an example, Deutsche Bahn (DB) itself, as the incumbent state railway enterprise, is a large RU. From a legal classification perspective, they are a "private company", but the Federal State owns 100% of the shares. While they may make public pronouncements about supporting single wagonload traffic, in reality, they are mainly interested in block (unit) trains operating over longer corridors, with minimal or no stops for pickups or "set-offs" in yards located between origins and destinations. They are also integrated with their own acquired, in-house logistics firm, named "Schenker", which now operates as "DB-Schenker". They provide a vertically and horizontally integrated and seamless package to the larger customers they target, as a forwarder. Their subsidiary, DB Schenker Rail, accounted for €5 billion of the €19.7 billion turnover DB Schenker achieved in 2015. However, it should be noted that as of August 1, 2015, DB Schenker Rail has restructured and integrated into *"a new traffic and transport division encompassing DB Schenker Rail, DB Long Distance, DB Regio and DB Sales. DB Schenker Logistics will be functioning as a forwarder and logistics unit only."* Source: Rail Journal 28 July 2015.

And, as of 1 January 2017, another restructuring has taken place which "…will include consolidating the Air and Ocean Freight and Land Transport Board Divisions to create a new division named Freight (COO). The aim is to tie these three product areas closer together to quickly improve integrated transport products and services and make better use of growth potential. A new organisational unit named Global Land Transport will also be created within this board division and will standardise and promote the development of land transport outside Europe. A new division called Commercial DB Schenker (CCO) and Contract Logistics will be created". Source: Eurologport.eu - December 2016.

For developmental and historical perspective, much can be written in narrative form about the financial performance of the units of Deutsche Bahn relevant to this research. To simplify and update observations succinctly, the following are two graphs describing the recent historical financial performance of the Cargo (primarily rail freight unit of DB) and the Schenker unit (the forwarding, trucking, air and ocean arm of DB), illustrating revenues and EBIT figures comparing both business units.

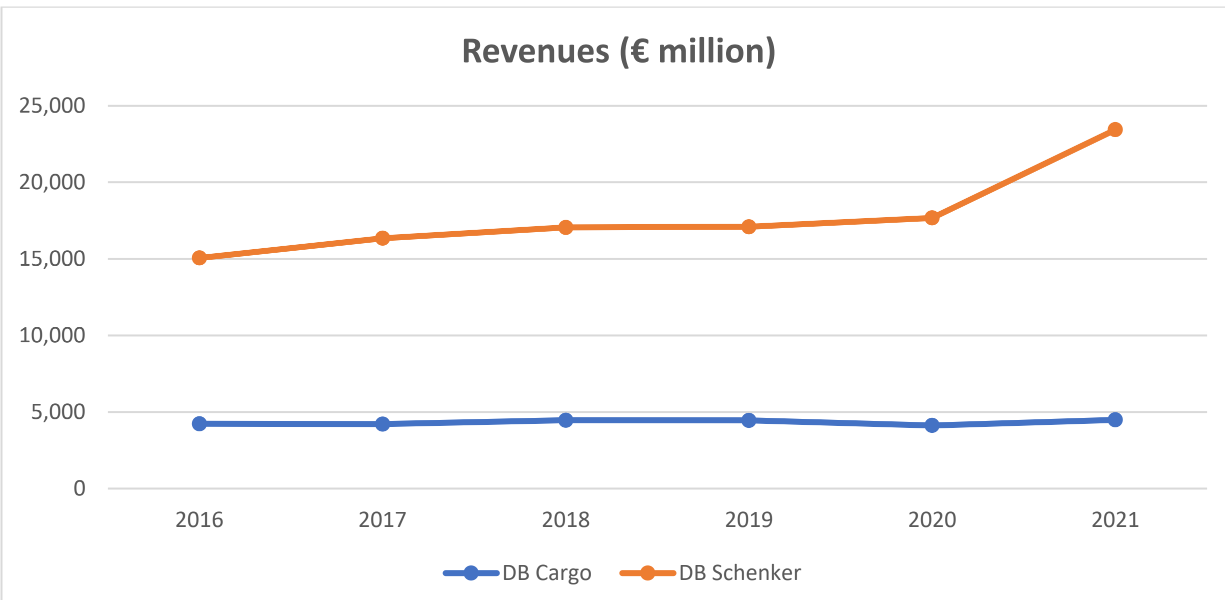

Figure 4: DB Unit Revenues 2016 – 2021

Source: Deutsche Bahn

Note the difference between DB Cargo, the rail side, with the revenue staying flat (or declining in 2020, due to Covid-19), compared to the sharp increase in revenues for DB Schenker, the unit with all other modes.

The year 2020, the entire world's economy was affected by the pandemic and Deutsche Bahn was similarly impacted. In 2021, their financial performance began the slow process of recovery, but the company's operating loss for 2021 was approximately €1.6 billion. In 2021, revenues rose to €47.3 billion, representing an 18.4% increase Y-o-Y and establishing a favorable upward trend, with demand for rail freight increasing. From 2020 to 2021, freight revenue increased by 6.3% and volume rose by 7.9%.

From 2020 to 2021, total revenues from DB Cargo (rail freight) rose by 8.9%, while revenues from DB Schenker, the forwarding, trucking, air and ocean arm of DB rose by 32.7%. However, DB began to report the Schenker unit as part of the "integrated rail system" and additional research is required to dissect the figures. Nevertheless, recovery was underway from Covid-19, as can easily be seen.

Figure 5 is more illustrative of the true prospects of rail vs. other modes. Note the sharper increase in losses for rail in 2020, explained by the pandemic. Yet, for the Schenker unit, and all other modes, EBIT sharply increased after the start of the 2020 recovery. The performance depicted in these graphs should give perspective, as to where DB management will focus.

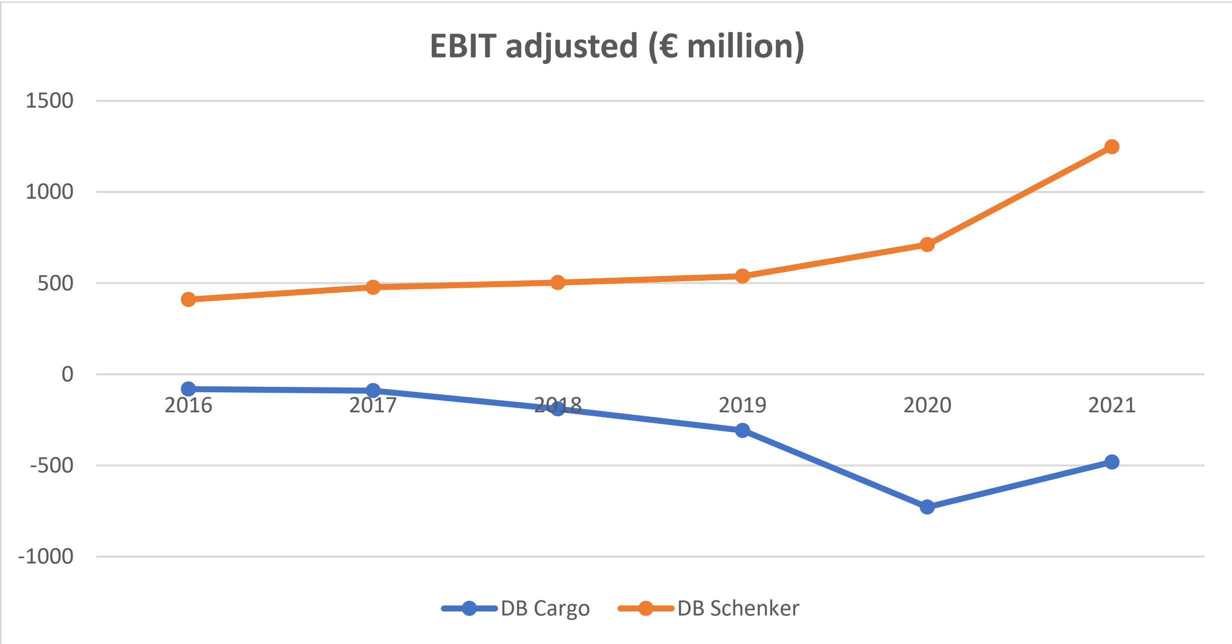

Figure 5: DB Unit EBIT 2016 – 2021

Source: Deutsche Bahn

There are also regional RUs that are wholly owned subsidiaries of Deutsche Bahn (DB). Within Germany, there are several examples of regional enterprises that have been established by DB to provide a more locally focused service and to cooperate with other smaller, local RUs for "final mile" delivery. Often, they work with the smaller RUs of various forms to establish joint rates for longer distance routings, which are seamless to the customer. In addition, they are more likely to be responsive to working with smaller RUs to develop "single wagonload" traffic, than Deutsche Bahn, their parent.

In the case of other countries, examples are the Belgian counterpart, formerly known as NMBS/SNCB, but now known as Lineas, as of 27 April 2017. This company, while it was owned by the Belgian government, was theoretically autonomous. The freight portion of the railway was previously operated as a separate division, known as "B-Cargo", but was partly privatized and renamed B-Logistics, after investment by the private equity group Argos Soditic, which took a 66% equity position in the company. As of 7 October 2015, Argos Soditic holds 68.9% of the shares and SNCB, the Belgian rail incumbent, owns 31.1% of the shares.

In Poland, the large, former incumbent is known as Polskie Koleje Państwowe SA (PKP). It is the second largest cargo operator in Europe, second only to DB. It is owned by the State 50% + 1 share and the remainder by private investors. They have entered into agreements with other publicly owned carriers, such as Pol-Zug, owned by the Port of Hamburg and together, they are a formidable combination that can easily undercut emerging operators seeking to compete on traffic between Hamburg and Poland, because they have the economic stamina to outlast any private competitor in this corridor, by keeping rates unprofitably low for any competitor.

In France, SNCF established a cargo enterprise division, encompassing previously established SNCF Geodis, a state-owned, integrated, subsidiary company. SNCF Logistics owns national railway operators in other EU countries. The names of those operators are Captrain DE, Captrain DK, Captrain Benelux, Captrain España, Captrain Italia, Captrain UK and Captrain Romania. In addition, SNCF Logistics operates Fret SNCF, the French national rail freight operator, the international forwarding operation Fret SNCF International and the wagon leasing firms of Ermewa, France Wagons, Akiem and Transengrais. SNCF has also diversified into the locomotive maintenance sector, establishing an enterprise known as Masteris.

CFL Cargo, the State of Luxembourg, through Chemins de Fer Luxembourgeois, has established an RU that serves not only Luxembourg, but has established wholly owned subsidiary operators in Germany and Denmark, known as CFL Cargo DE and CFL Cargo Danmark, respectively. CFL Intermodal is their wholly owned subsidiary CT operator and offers 20 rail connections per week from Luxembourg to the North Sea Ports, as well as Northern and Southern Europe. Table 3 shows a partial listing of examples of present and former incumbent RUs.

Incumbent Companies	Incumbent Country	Rail	Rail Country
BDZ	Bulgaria	Bulgarian State Railways	BG
Căile Ferate Române	RO	Incumbent freight operator	RO
ČD Cargo, a.s.	Czech Republic	State-owned Czech railway operator focused on freight operations	CZ
DB Cargo	Germany	DE incumbent spinoff	DE
Ferrovie dello Stato	IT	Freight portion of state railways of Italy	IT
Iarnród Éireann	IR	Freight portion of Irish Rail	IR
Koleje Czeskie Spółka z o.o	Czech Republic	Koleje Czeskie Spółka z o.o (CD Cargo a.s.) CZ Incumbent spinoff	CZ, PL
Koleje Czeskie Spółka z o.o	Czech Republic	CD Cargo Poland - CZ Incumbent spinoff	PL
Lietuvos geležinkeliai	LI	Incumbent freight operator	LI
Magyar Államvasutak Zrt	HU	MÁV Cargo Zrt	HU
PKP Cargo SA	PL	Incumbent freight operator	PL
SBB	CH	Schweizerische Bundesbahnen - Chemins de fer fédéraux - Ferrovie federali svizzere	CH
SNCF Logistics	France	Includes Fret SNCF, Captrain, France, Ermewa (leasing)	FR
ZSSK CARGO	SK	Freight portion of state railways of Slovakia	SK

Former Incumbents	Incumbent Country	Rail	Rail Country
Lineas	Belgium	formerly known as NMBS/SNCB, but now known as Lineas, as of 27 April 2017	BE

Table 3: Partial Listing of Example Incumbents or Former Incumbents

Source: Self-compiled

3.4.2.2 Integrated Companies as RUs

Integrated RUs are often joint ventures between railway operators and/or have shareholder participation from shipping lines and/or terminal operating companies. These integrated RUs have been and are active in not only serving major terminals and routes, but further developing existing, as well as new route paths. Acquiring and equipping locomotives for international operations has been undertaken by both integrated and regional RUs and has contributed to the development of the numerous corridors. They facilitate border-crossing operations with locomotives able to operate under the different signaling systems of each country and if electric locomotives are used, can operate under the multiple, different voltages of each country. These RUs also arrange for crew changes at the border points to ensure that the trains continue without delays. This means a seamless traction operation of shuttles to/from Poland, Czech Republic, Germany, Belgium, The Netherlands and numerous other countries, in cooperation with major shipping customers. Table 4 shows a partial example listing of integrated companies as RUs.

Integrated Companies as RUs	Country - Mother Co.	Rail	Rail Country
Bega Group	Romania	Rail, industrial parks and amusement parks	RO
Budamar Logistics	Slovakia	LokoRail, a.s., Central Railways a. s., Inter Cargo Sp. Z.o.o. (PL), ODOS Cargo a.s. (shunting), Bulk Transshipment Slovakia (bulk terminal & storage & transport)	SK
CFL Cargo	Luxembourg	Established wholly owned subsidiary operators in Germany and Denmark, known as CFL Cargo DE and CFL Cargo Danmark, respectively. CFL Intermodal is their wholly owned subsidiary CT operator	
Colas Rail	France	Owned by Bouygues S.A.- French industrial group	UK
Hupac	Switzerland	Rail, trucking, terminals, CT, freight forwarder	CH
Metrans	Czech Republic	Rail, trucking, terminals, CT, freight forwarder	CZ
Lineas	Belgium	Rail, trucking, terminals, CT, freight forwarder, oil terminals Equip leasing and maint., former incumbent NMBS/SNCF	BE
SNCF Logistics	France	Operates SNCF Fret (rail freight operator), Fret SNCF International (forwarding), Ermewa & France wagons (wagon leasing), Akiem (locomotive leasing), Masteris (locomotive maintenance)	FR
Transfesa	DE, ES	Rail, trucking, terminals, CT, freight forwarder	DE
Unicom Companies	Romania	Rail, trucking, terminals, CT, freight forwarder, oil terminals Equip leasing and maint.	RO

Table 4: Partial List of Example Integrated Co's as RUs

Source: Self-compiled

3.4.2.3 Regional RUs

Outside of Deutsche Bahn, the smaller, regional RUs often enter into cooperative agreements to expand their geography, either with Deutsche Bahn, other integrated RUs or other regional RU's. Many regional RUs have minimal assets and enter into cooperation with integrated or other RUs with wagons, as well as rolling stock leasing companies to ensure the right wagon type is supplied to their customers. Sometimes, it is the customer who establishes a relationship with a leasing company, however, this is often facilitated by the regional RU.

As they are often much more entrepreneurial than DB or even the major integrated RUs (which are most likely to concentrate their efforts on their own customers and partners), they will actively seek revenue from diverse sources.

Some examples of ancillary revenue sources are:

- Reactivating existing sidings for new or more traffic
    - Entering into construction contracts to rebuild or add new sidings
    - Planning and construction management
    - For construction or rehabilitation of railway sidings, there are many existing federal and state funding programs. They often help the customer in preparing applications and applying for funding programs

- Special and passenger excursion trains

- Special cargo train movements: they can organize their own trains with all the elements required: locomotives, wagons, qualified personnel, schedules and shunting

- In connection with above, there are RUs that operate trains for different railway lines in Germany on contract

- Special local “inland terminal” development; RUs can accommodate the logistics demand for sending and receiving block trains to a local site for loading and unloading or handling station (terminal), for the handling of swap bodies, containers or loading bridges (ramps)

- Special work trains for track work; many offer qualified crews and locomotives in the power range from 860 to 1135 kW (1170 to 1550 hp), with or without remote control

- Special “exposure trips”; after major track renovation work, a minimum of 50,000 tons must be operated over the track, before it is considered safe to operate at normal (top) speed for that segment of track. Without this service, there would be “slow orders” imposed on that area of the line, resulting in delays after construction work. By offering "service load trips", they "iron out" the track structure, allowing a quicker return to service of the affected line

- Rolling stock (vehicle) transfers; often wagons and/or locomotives must be transported or "ferried" to and from workshops. Regional RUs will help facilitate these moves for delivery, for either new or used rolling stock. Often, customers also request testing of railway equipment and with their qualified personnel, this can be performed by the RU

- Special services: in connection with the above, "concierge services" are often provided to ensure expedited and damage-free handling of rolling stock. This service is of particular value to owners of passenger, unique and/or historical rolling stock, which is subject to vandalism or damage from improper handling by crews inexperienced or unfamiliar with the equipment. RU personnel help ensure that equipment is delivered expeditiously and without damage

- Shunting and Terminal Operations; once wagons arrive at the customer's yard or siding, the wagons will have to be positioned for loading or unloading and then moved out of the way. In general, smaller locomotives are used for this, as they are sufficient for single-digit numbers of wagons

3.4.2.4 RUs affiliated with Incumbent Railways

These RUs are involved with the delivery of rail services over public and non-public networks, services for rail freight and the provision of services for railway infrastructure companies, as well as certified maintenance and repair of railway vehicles. Often, they are the result of the spin-off of the branch lines of large companies in the petroleum or chemical sectors, similar to lines operated in the US, on behalf of the Class I railways. They also operate large railway siding networks, within the infrastructure of large manufacturing, agricultural and petrochemical processing plants. This is analogous to private shunting operators in North America, which may not operate a railway, but operate internally within and over a plant's railway infrastructure. Table 5 shows a partial example listing of companies owned by incumbents, including RUs.

Companies Owned by Incumbents	Incumbent Country	Rail	Rail Countries
Captrain	FR	Owned by SNCF (Rail Logistics Europe), includes Captrain DE, DK, Benelux, España, Italia, Romania & UK.	BE, DE, DK, ES, IT, RO, NL & UK
CFL Cargo	LU	Owned by Société Nationale des Chemins de Fer Luxembourgeois (CFL), subsidiaries are CFL Cargo DE, Danmark	LU
DB Cargo UK	DE	Owned by DB, formerly English Welsh & Scottish Railway (EWS)	UK
Green Cargo AB	SE	Owned by government of Sweden	SE
Rail Cargo Group	AT	Owned by OBB, the freight arm of the Austrian Federal Railways	AT
SNCF Geodis	FR	Predecessor to SNCF Logistics	France
SNCF Logistics	FR	Operates SNCF Fret (rail freight operator), Fret SNCF International (forwarding), Ermewa & France wagons (wagon leasing), Akiem (locomotive leasing), Masteris (locomotive maintenance)	France
Südostbayernbahn	DE	Subsidiary of DB and freight services taken over by DB Cargo	DE

Table 5: Partial List of Example Companies + RUs Owned by Incumbents

Source: Self-compiled

3.4.2.5 RUs non-affiliated with incumbent Railways

These operators provide shunting services at terminals, transport by rail (special trains, block trains and "spot-hire" trains), including path ordering, trans-loading (for combined transport), special cargo handling situations, track and siding maintenance and construction, first/last mile delivery and one-off (spot) locomotive hire, as well as staffing, such as drivers. They are also involved with establishing and operating international shuttle trains.

3.4.2.6 Local RUs (terminal railways, very short-haul, transfer/shuttle railways)

These RUs are mostly smaller enterprises that operate locally, from as little as 1 km to an approximately 50 km (or more), radius. Often, they have been organized to either preserve railway service in a line abandonment program, such as that implemented by DB under the "Mora-C" program, whose intent was to "rationalize" unprofitable branches. Faced with losing service, entrepreneurs stepped in and organized enterprises to operate the heretofore unprofitable lines, however regarded as necessary to preserve economic links for their local communities. In other instances, they have re-established service over formerly abandoned lines, but with capital raised locally, repairs and renovations were made to the infrastructure to allow the line to return to service. Often, one of the driving forces behind these local RU enterprises are industries that need the rail service, but cannot attract a former incumbent railway's attention and are in danger of becoming captive to more expensive motor carrier transport. This category is the closest to the North American, Class III short-line railway model.

Table 6 on the following page summarizes the typology of RU's.

Typology of Railway Undertakings (RU's) in North America and Europe

North America	Size	Scope	Notes	Europe	Size	Scope	Notes
Class I Railroads	Large	National	Total of 5 in the US and 2 in Canada (also operating in the US)	Incumbent (former State) Railway	Large	National	Former state railways
Class II Railroads	Medium	Regional	Usually acquired from Class I's or were former Class I's. Total of 14 US and 1 in Canada. ***Public or private infrastructure***	Regional RU's	Medium	National or regional	
Class III Railroads affiliated with Class I	Small	Local & regional	Usually only connect with 1 Class I.	Regional RU's affiliated w/incumbent	Medium	National or regional	
Class III Railroads non-affiliated with Class I	Small	Local & regional	Often have multiple Class I connections.	Regional RU's non-affiliated w/incumbent	Medium	National or regional	Infrastructure owned or not owned by RU
Class III Railroads owned by holding companies	Small	Local & regional	Portfolio of small railroads - US and/or Canada, sometimes international	Local RUs owned by public infrastructure body	Small - Medium	National or regional	
Class III Railroads	Small	Local & regional	Local and/or switching carriers. Total of 546 Class III railways in the US. ***Public or private infrastructure***	Local RUs privately owned (terminal railways, very short-haul, transfer or shuttle railways)	Small - Medium	Local & regional	Terminal railways, very short-haul, transfer or shuttle railways
Industry railroads	Small	Very local	Often intra-plant	Local RUs privately owned	Small - Medium	Local & regional	
Contract switching	Small	Very local	Contract shunting operations within a factory complex	Local RUs privately owned	Small	Local & regional	
				Integrated	Large	National or regional	

Table 6: Typology of Railway Undertakings (RU's) in North America and Europe

Source: Own composition

3.5 Service Models

The narrative in Chapter 3 distills down to identifying the different enterprise typology combinations that have the highest potential of commercial viability, given the landscape of market conditions, governmental regulations, competition between modes, cost structures and economics and requiring scale to be achieved.

There are two fundamental categories that define the model framework:

- The service model, defined as the relationships the RU has with the marketplace for the source of traffic.
- The operating model, defined as the relationship of the RU to the underlying infrastructure.

Addressing the RU service model, some guidance on this topic can be found in ***"Implementing Change in the European Railway System – Selected Findings from REORIENT"*** **(2007)**, a report issued in with support of the EC DG TREN mission, with the participation of seven partners from the US and Europe. Within the report, they summarize with four basic service models, mostly operative within Europe:

1. RU (operator) and 3PL are integrated and share business responsibilities

2. RU (operator) and anchor customer (shipper) make direct agreements

3. Agents of RUs (freight forwarders) make agreements with shippers

4. 3PLs (logistics company) make agreements with customers and subcontract with an RU/traction provider

In addition to the four service models above, as suggested in the **"Reorient"** report, there is a fifth service model, summarized below and detailed later in the chapter.

5. RU (operator) and all customers (shippers) make direct agreements and/or originate/terminate traffic to/from connecting RU(s)

Figure 6 summarizes the characteristics of the four basic service models, plus a fifth model explained in greater detail further in this chapter.

With respect to RU operating models, in order to maintain approximately equivalent comparisons, the infrastructure ownership needs to be taken into account for both the newly liberalized non-North American RU operating environment, as well as the North American operating environment. The standard North American operating model is that the RU owns and maintains the infrastructure.

However, financially, it is difficult to compare the operating models, if the RU infrastructure responsibilities are not at least approximately matched. Therefore, to facilitate a more equal comparison, it would be more appropriate to examine North American RUs whose infrastructure is either owned by the public sector or is leased, either from public or private ownership.

In those models, the actual infrastructure owners are compensated in varying ways:

1. A per loading unit (wagon or container) charge

2. A percentage of revenue (gross or net, depending on contract)

3. RU participation of infrastructure maintenance costs on a percentage ratio basis

4. A flat fee basis

5. A “wheelage” charge – charge per wagon per unit of distance (example: $ per car mile)

6. A “per train” basis charge – charge per train per unit of distance (frequently used for Amtrak or commuter rail operations over large Class I railroads).[40]

7. A “haulage” rate charge – generally for trains of one RU operating over another RU for purposes of accessing terminals, another otherwise physically inaccessible interchange point or reaching a customer on a physically disconnected portion of the RU. This rate assumes that the trains operated on your behalf use another railroad’s (not yours), crews and locomotives hauling your cars and the train revenue earned stays in your revenue account.

[40] Historically, a $12.50 per mile charge was imposed on Amtrak in the original operating contracts over Class I railroads. Under these circumstances, this rate was not intended to be revenue producing and was used as an offsetting cost reimbursement for infrastructure maintenance.

8. Trackage rights charges involve the use of your locomotives and crews hauling cars on someone else's railroad, but the revenue earned stays in your revenue account.

9. A "detour" rate – a cooperative arrangement that railways have with one another, due to a "force majeure" (floods, forest fires, volcano, earthquakes, civil insurrections (riots), etc.), as well as temporary conditions, such as derailments, bridge or tunnel collapse, avalanche, etc. $12.50 per train per mile, with a BN "pilot" (a locomotive driver familiar with and qualified to operate over a specific territory or line segment).

10. Joint facility rates – Amtrak

11. Trackage rights - your engines and crews hauling on your revenue account.

For the small to medium sized (Class II or Class III railway), the most common formulas used are a combination of options one, two and three. Number four, a flat fee, is rarely used and formulas five, six and nine are not appropriate for calculating ongoing basic cost structure. Numbers seven and eight could be possibilities for one RU operating over another RU's track.

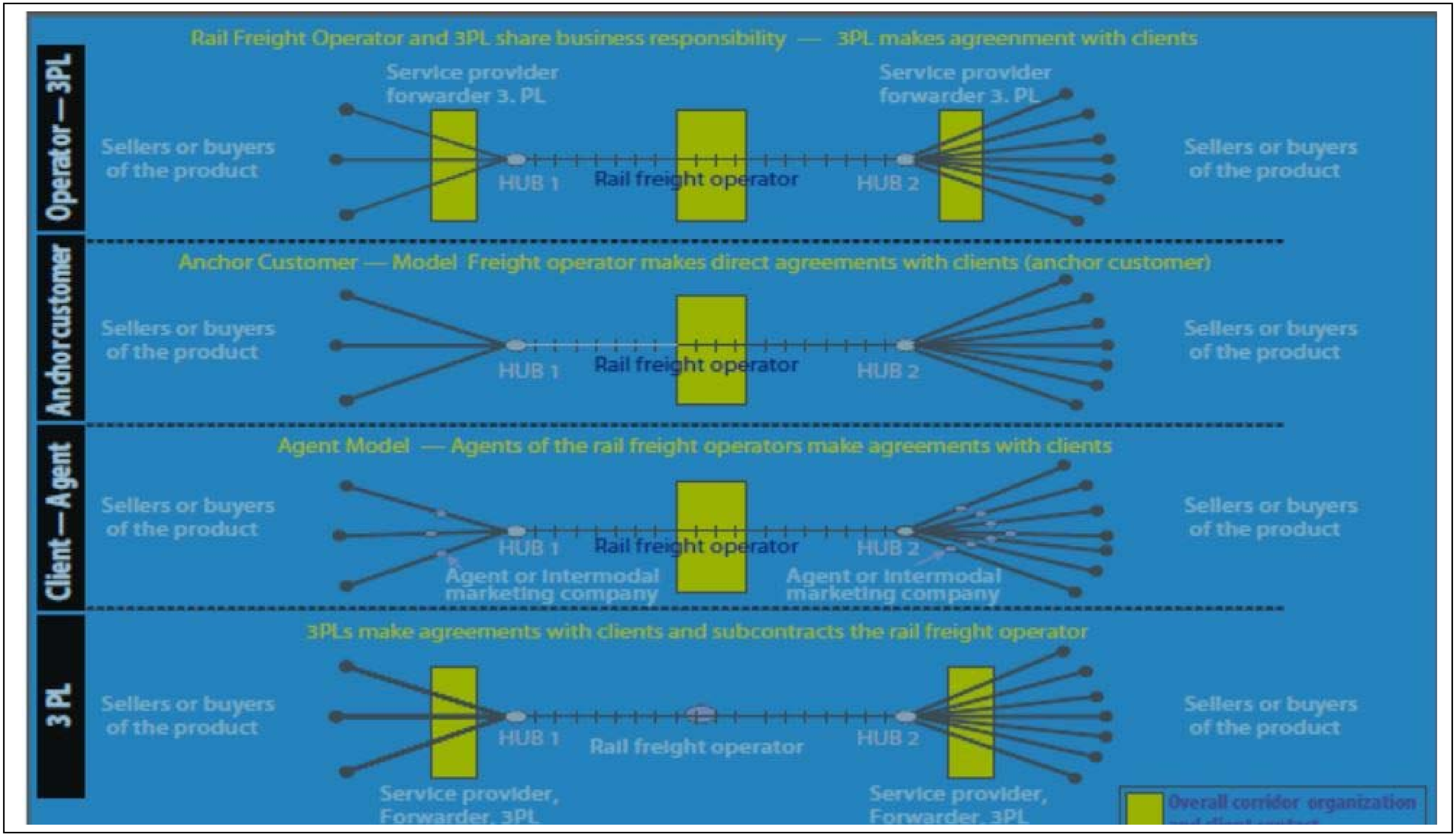

Figure 6: Business Model General Configurations

Source: Reorient Publishable Final Activity Report (2007)

3.6 Service Model Characteristics

The characteristics of the five service models to consider are:

Model 1: RU (operator) and 3PL are integrated and share business responsibilities

Pros:

- The business interests of the RU and the 3PL are aligned, in that the functions of each feed each other's success.

- Functionally, they support each other and it is in their respective best interests to develop complementary processes and cross-training of personnel to ensure that there are clear channels of communication and backup systems.

- Being that they are integrated, it is unlikely that they will work with competitors and undermine their joint efforts.

- 3PLs have the administrative infrastructure and technology to handle the traffic data requests and satisfy the quality of information demanded by their customers.

- There is more joint control of the customer relationship, than if the two were separated.

- The 3PL handles the first/last mile (PPH) segments.

Cons:

- The operating cultures may clash, in that operators view their functions through the lens of operations execution, the performance of which they are judged upon. That may bring about a shorter-term perspective, as regards growing the business. The 3PL side of the enterprise, on the other hand, will have the perspective of pleasing the customer, at the expense of less than optimal or unprofitable operating practices.

- The 3PL, to please the customer, may also be tempted to consider road transport.

Model 2: RU (operator) and anchor customer (shipper) make direct agreements

Pros:

- The RU and the anchor customer have a close working relationship that reduces the need for the operator to continuously search for customers for recurring revenue flows. This allows the operator to concentrate time and resources on satisfying the anchor customer.

- Operations will be built around the needs of the anchor customer, rather than the service offer being diluted by the needs of other customers.

- The operator is compelled to flexibly accommodate the needs of the anchor customer, allowing the customer to be competitive with the transport service offerings.

- Theoretically, the operator has more control of the relationship between themselves and the anchor customer – there is no one in the middle.

Cons:

- There is no guarantee that with growth, the anchor customer will not seek to use other modes or even other rail operators.

- Not being integrated financially and organizationally means that their respective commercial interests could be competing, resulting in one or both being disadvantaged.

- Long term loyalty is in question, making it difficult to make long term capital decisions.

- Dependency on a single customer

- The operator may be handling the first/last mile (PPH) segments.

- While the operator may have the comfort and security of the anchor customer's business, they are simultaneously tied to the fortunes of that customer. What happens if the anchor customer suffers adverse business events, either sector related or due to larger global trends?

Model 3: Agents of RUs (freight forwarders) make agreements with shippers

Pros:

- Freight forwarders usually have access to a large base of customers to market the RUs services.

- Freight forwarders usually have a geographic focus, which coincides with the operational characteristics and area focus of the operator.

- Freight forwarders have the administrative infrastructure and technology to handle the traffic data requests and satisfy the quality of information demanded by their customers.

- The 3PL handles the first/last mile (PPH) segments.

Cons:

- There is no specific anchor customer, other than the freight forwarder itself.

- It is more difficult to plan specific services, given the diversity of freight forwarder customers' needs.

- There is no loyalty or commercial ties to ensure the operator will continue to receive traffic, especially if there is an external network event or unfavorable regulations hobbling the operator's ability to perform and/or deliver economically.

- Given above, the freight forwarder may be under pressure by their customers to select road, resulting in the loss of traffic.

- The operator is exposed to low-cost truck operators who may solicit traffic by undercharging, due to their low costs. In that case, the freight forwarder may elect to be a rational economic player, resulting in the loss of traffic to the operator or forcing the operator to deliver services below cost to keep the business.

- Given the variability of traffic and unknown volume, it would be difficult for the operator to plan long term capital investment needs.

- The operator has less control or even direct access to the customer in this relationship.

- Dependency on the freight forwarder agents, without the operator having an established base of traffic.

Model 4: 3PL (logistics company) making agreements with customers and subcontracting with an RU / traction provider

Pros:

- The 3PL aggregates traffic from numerous customers, achieving traffic volume and scale for the operator (similar to the freight forwarder relationship)

- 3PLs have the administrative infrastructure and technology to handle the traffic data requests and satisfy the quality of information demanded by their customers.

- There is less demand on the administrative and data side, allowing the operator to focus on logistics and service delivery.

- The operator can contract with multiple 3PLs for traffic, but as a practical matter, only if the RU is also operating in territories that the 3PL is not, eliminating competitive conflicts.

- The 3PL handles the first/last mile (PPH) segments.

Cons:

- There is less joint control of the customer relationship, than if the two were actually integrated.

- The operator is separated from and dependent on the 3PL for the customer volume and relationship.

There is an additional model that was not taken into account in the "Reorient" research, which could be possible in both newly liberalized service environments and in North America. The North American operating and service models tend towards this model.

Model 5: RU (operator) and all customers (shippers) make direct agreements and/or originate/terminate traffic to/from connecting RU(s).

Pros:

- The RU has a direct connection with the customer and can more clearly and accurately identify service issues and price sensitivity vs. having the additional layer of another enterprise, which may mask commercial nuances to the transport story.

- The RU can cooperatively plan with the customer, as to their service needs and perhaps even assist them in developing additional site infrastructure to facilitate the movement and throughput of loaded and empty wagons.

- The RU can more effectively negotiate with connecting RUs for more optimal service, transit times and rates on behalf of the customer (especially for the longer distance routes in North America)

- The RU can make effective arguments on behalf of the customer when public jurisdictions impose problematic changes to infrastructure through planning initiatives or changes in public policy. Often, these changes result in some form of restrictions or other undesired outcomes negatively affecting the customer and the RU. An enterprising RU can often team with the customer to develop effective arguments to properly advise policy makers of the adverse effects of the contemplated changes or policies, as well as natural allies whose professional missions, within government, are aligned. Examples would be local and regional governmental economic and industrial development offices.

- The RU can assist in organizing infrastructure to be built on the customer's site, where the customer would own the track and improvements, but might not have the technical expertise to execute the needed additions and changes Example: building or extending a sidetrack.

- The RU can often facilitate the acquisition of land for customers who would like to expand or to assist new customers in finding land on which they can locate their enterprises, both with commercial landowners and units of local/regional government, such as local economic and industrial development offices.

Cons:

- The RU has the additional responsibilities of directly satisfying existing customers and maintaining the relationship.

- The RU has the additional responsibility of finding new customers to grow the enterprise.

- The RU may have less input into the customer relationship if the transport decision is made elsewhere, such as if the corporate offices of the customer not located locally.

- The RU may have less influence on the customer relationship if the customer's production input shipments are decided by its suppliers or their 3PL/freight forwarder and not the customer.

- The RU may have less influence on the customer relationship if the customer's production output shipments are decided by its customers or their 3PL/freight forwarder and not the customer.

- The RU may have less influence if the connecting RU(s) are competitively uncooperative and try to organize transshipments from sites on the connecting carrier's network (e.g., transloading), effectively excising them from the revenue stream. (A common problem behavior in North America)

- The RU may have no influence if the connecting RU(s) are competitively uncooperative and own the underlying infrastructure itself, as well as the interchange with the connecting RU's network and deliberately degrade service and rates to undermine the RU.

3.7 Service Model Selection and Rationale

In synopsis, the following dominant factors emerge as rationales for this selection.

Model 1 - RU (operator) and 3PL are integrated and share business responsibilities

In the case of Model 1, the reasons are that the business interests of both the operator and the 3PL are aligned, assuming they are two separate entities, but linked in a joint venture or belong to the same "mother company" but are two separate divisions. The cultural disadvantages of having two different missions are likely to be small, in the larger scheme of things.

Model 2 - RU (operator) and anchor customer (shipper) make direct agreements

For Model 2, while there is simplicity and comfort for an RU to focus on an anchor customer and without the complexities of blending other customer's needs and performance demands, there still are vulnerabilities. For example, what are the characteristics of the anchor customer's industry sector? If the industry sector is cyclical in nature, such as manufacturing consumer products of a discretionary nature or even consumer durables, in an economic downturn, reduced product demand may diminish traffic. A sector is cyclical if the prerequisite for prosperity is a strong economy, where cyclical companies' fortunes depend on the business cycle. Examples of these types of industries are:

- Steel makers, such as Arcelor Mittal, US Steel, Nucor
- Machinery manufacturers, such as Caterpillar, Volvo trucks, MAN, the automakers (and their parts suppliers)
- Chemical companies, such as Dow Dupont, BASF (plastics)
- Lumber – affected by housing starts and negative population growth, resulting in lower family formation and consequently slower housing starts

In a secular industry sector, there is less risk of reduced demand in an economic downturn or cyclicality, because the demand for the final product and its input materials is consistent or even growing. In the case of transport demand, examples of companies where steady and consistent demand are a characteristic are:

- Foods and consumer packaged goods, such as General Mills, PepsiCo, Coca-Cola, Procter & Gamble, Unilever PLC, B&G Foods, Constellation Brands, etc.
- Cleaning products, such as Proctor & Gamble, Unilever, Clorox, Newell Brands (Rubbermaid)
- Paper and plastics packaging, such as Kimberly Clark, Boise Cascade, Stone Container
- Household products, such as Clorox, Newell Brands (Rubbermaid)

- Breweries and distillers – few people would forgo a good beer, wine or other adult beverages.

Sectors that are secular insulate from cyclicality and curtailed demand in economic downturns.

And, in either scenario, if production shifts to lower cost regions, especially given global trade developments, such as China's "*One Belt and Road Initiative (BRI)*", an RU could find their dependency on the anchor customer to be misplaced. Regardless of the scenarios, the RU is too dependent on the anchor customer and is vulnerable.

Model 3 - Agents of RUs (freight forwarders) make agreements with shippers

In the case of Model 3, it is better for the RU to cultivate multiple sources of traffic, through the network of relationships developed by the freight forwarders. Additionally, the RU and freight forwarders could be focused on serving the same regions and thus have some understanding of the market segments and their demands.

However, if the RU is not integrated or at least in close cooperation with a trucking firm for PPH, the RU could be vulnerable to the freight forwarder selecting an RU who does have some form of integration with trucking. In general, freight forwarders will select any option that results in consistent performance to their customers and if there is a risk that performance will not be realized, the RU will not be selected. While price is also an important factor, consistent performance, in the form of delivery reliability, is equally, if not more important, in this context.

If the RU is not integrated with the freight forwarders, there is no specific loyalty to the RU, other than the intangible reservoir of good will and the perishable link of their business relationship. If the economics dictate, it would be just as easy for the freight forwarder to give the business to a low-cost driver operating from the eastern countries of the EU.

Model 4 - 3PL (logistics company) making agreements with customers and subcontracting with an RU / traction provider

In the case of Model 4, the 3PL is the interface and buffer between the customer and the operator and handles difficult details that might absorb the administrative resources of an RU that may not have the administrative depth of focused and trained personnel, as well as the IT resources to follow-up on the myriad details of customer requirements. This would be especially true if the RU is only a traction provider, alone.

This model works only if the 3PL exclusively uses the RU, at least within the territories it operates or if the two are integrated. If the 3PL uses other RU's operating within or between the same territories, then there is no difference between this model and model 3.

Within the two service models, there are variations that will present themselves in the research and will also be explored. Those variations could reveal the desirability of adding complementary functions to the models, or not. In these cases, the variations may also be explored. The research will focus on the cost structures and modeling of these two business service models, as an initial launch typology, with the understanding that further subcategories and variations may emerge.

Model 5 - RU (operator) and all customers (shippers) make direct agreements and/or originate/terminate traffic to/from connecting RU(s)

Model 5 has a strong advantage of an RU's insight into the customer's viewpoint, through the direct vector of communication, which eliminates any filtering that may exist to transmit nuanced feedback that could mean the difference between being selected as a transport option or not.

An RU has the peer advantage of negotiating with cooperating or connecting RUs from an informed stance, as the relevant issues and questions can be addressed from a fellow operator. The likelihood of answers that do not directly address the issue is remote when one RU poses questions to another RU.

An RU, positing from an informed stance on a spectrum of issues can advocate effectively on the customer's behalf with local (or higher) regulatory authorities. From an industrial and economic development perspective, the RU will have a good overview, as to technical requirements of the improvements needed to land acquired for site locations.

The negatives are that the RU management's bandwidth will be consumed with maintaining the relationship. Another reality could be that the actual transport decisions are either made elsewhere from the site requiring transport services and/or the customer's transport decisions are made by a relationship with a 3PL or freight forwarder. Or, a competing RU may choose strategic behavior by not cooperating with the originating RU, with the viewpoint of acquiring their customer.

Outside of the service models, there are other RU variations to consider, relative to the ownership and physical attributes of the railway line.

In terms of the geographic scope of a line (route), some general characteristics should be reviewed. Each RU operating in territorial increments of scale has its own pros and cons as summarized below.

In general, with railway lines that are very local, local or regional, the cost structures will be smaller and more manageable. Like the trucking industry today, employees are easier to attract, if they are not away from their homes and families for extended periods, especially with the generally aging workforce.

Also, it is a given that the span of management control is much easier if the geographies are not dispersed over a wide area and or widely separated e.g., different operations owned by the same enterprise, but in distant territories that do not connect.

Very local and local RU's may also have the advantage, especially in North America, of line density. More wagon traffic per km results in economies of scale, with respect to costs, because supporting facilities and railway lines have fewer km to maintain, as well as having slower speeds, resulting in lower maintenance costs.

With respect to ownership, especially in North America, in most cases, the infrastructure is owned by the RU and a railway line with greater traffic density and / or very localized is generally preferred, because of reduced track maintenance and operating (labor) costs. However, it is not necessary that the underlying track infrastructure be owned by the RU and as can be demonstrated with some lines in North America. The public sector often pays much more than the RU for capital and maintenance expenses reinvested into a line, because of the recognition by government of the importance of retaining the line, seen as basic infrastructure.

An alternate variation, more likely possible in North America, is to not even establish a railway enterprise at the outset, rather, to simply begin as a terminal and storage facility, eventually evolving into an actual RU. This would especially be the case for smaller, capital constrained startup enterprises. Generally, such enterprises begin where there is already an established customer base, that may or may not have rail service, but, within an industrial park that has existing rail installed. Initially starting with the development of ancillary businesses, such as railcar storage, trans-loading services (first/last mile or "PPH"), it is possible to minimize startup risk and gradually build up the business to scale.

Yet another North American model involves leased track from another RU that has a high-cost structure. By leasing the railway line out to the RU with a lower cost structure, positive results can be achieved, such as increased service (frequency) levels, resulting in, at the least, retained traffic if not increased traffic levels. Also, in that way, high capital costs for acquisition of the railway line are not incurred. Often, railways are valued based on "across the fence" valuations vs. as railway right-of-way, which can be vastly different. The "across the fence" valuation basis assumes the use of the linear real estate for the same functional purpose as land located "across the fence" and not dedicated to railway operations, valued considerably higher. [41] [42]

Another picture now begins to form, with a combination of layers of service and ownership models overlain.

This now leads to other variations of business models, beyond the original ***"Reorient Service Models"*** matrix, described earlier. For example, the business model can take the form of a small, regional or local RR with the two aforementioned service models, whose underlying infrastructure is owned by the public sector and has a dense, localized traffic base, but is operated privately.

The category of RU that corresponds to those attributes is a local terminal railway serving a port, yard (or system of yards) or an industrial and warehousing district.

Reviewing the characteristics, in terms of the most optimal service models, further research yielded literature to reference. There has been a series of "good practice" reports sponsored by the EU Marco Polo program, the goal of which was to explore methodologies to effect shifts of cargo from road to rail. A report issued by KombiConsult was commissioned by the EU and the relevant report is ***"Cosmos Project-Business Models for Intermodal Transport" Good Practice Number 13, (2013)***, which became a reference to cross-check and compare with the rationale for selecting the business models referenced further in this section.

Based on conclusions reached through this researcher's past observations, which corroborated with the content of the ***"Good Practice Manual No. 13"*** report, of those service models, three emerged as a starting point for the most viable and they are:

Model 1: RU integrated with a 3PL
Model 4: 3PL (logistics company) making agreements with customers and subcontracting with an RU / traction provider
Model 5: RU (operator) and all customers (shippers) make direct agreements and/or originate/terminate traffic to/from connecting RU(s)

Models 1 and 4 have been selected, because they are judged to have better possibilities of developing scale, particularly in newly liberalized service environments. In the case of Europe,

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[41] There are many operational reasons why this is so, ranging from removing empty wagons more quickly, allowing loaded wagons to be expeditiously unloaded, resulting in greater throughput and higher traffic levels
[42] Greater throughput can also result in lower operational costs through more cars handled during operations over a specific line segment, as well as reducing "car hire" costs on other railroad (RU), owned cars.

the reasons for this are because the distances between origin and destination are often insufficient to capitalize on the efficiency of rail, generally realized over distances greater than 500 km. The two model variations offer the prospect of shipment aggregation to partially offset the shorter distances through volume. Similarly, the RU must partner with a 3PL or freight forwarders whose commercial interests are aligned with the RU. In the European environment, the customers are often too small to generate large shipment quantities and the 3PLs and freight forwarders are in a better position to aggregate traffic to achieve the scale necessary for rail transport. The key assumption for models 1 and 4 to work is that their respective economic interests are commonly aligned, in the form of direct economic benefit and/or being linked together in the same holding enterprise.

Model 5 was also selected, because the RU has a direct connection with the customer, bypassing any unintended (or intended), communication filters or obstructions from another party in the customer relationship. Small details can often be the difference between success and failure in capturing the customer's business by obtaining favorable rates and service levels from connecting RU's.

With respect to adverse events affecting the RU and the customer (regulation and policy), the RU that has a close working relationship with the customer and the regulators will have a higher probability of a successful outcome, compared to an RU who is remote and disconnected.

Regarding negotiations with a connecting RU for more favorable rates and/or service frequencies, as well as enhanced operating efficiencies, the operating RU will have the advantage of negotiating from a knowledgeable and informed position, through their experience as an active and engaged transportation practitioner.

The negatives of the additional responsibilities of directly satisfying existing customers and maintaining the relationship are more than offset by the increased and direct communication with the customer, which will ultimately help in retaining or increasing traffic levels. The prospect of a perennial search for new customers is an established constant for most RUs, anyway and does not generate any new or unexpected ongoing burdens.

As regards communicating with remote traffic decision-makers, those barriers would exist anyway, as those duties would be handled by the partner 3PL / freight forwarder. At least under the Model 5 scenario, there would be more active engagement, with the customer assisting and perhaps even guiding the discussion.

Finally, as regards a toxic relationship between the RU and the connecting RU, while it is possible, that situation is not likely, given their mutual interests. However, if there are intractable positions taken by the connecting RU affecting business, in the case of connecting North American-based RUs, there are remedies available through the Surface Transportation Board (STB) and through arbitration processes.

In summary, aligning the interests of complementary enterprises between RUs and other non-competitive stakeholder counterparties is sensible.

There is some gradation of each business model that will result in a degree of reduced costs and/or increased revenues, in addition to the increase in scale potential of the participants, but matched to an RU's unique set of business relationships and circumstances.

Chapter 4 – Methodological Framework

As a brief introductory summary, the framework to determine profitability distills down to collecting the data, selecting the model to use and then analyzing the data. Figuring out broadly what data is needed e.g., the specification and the structure is foundational. When that is known, then collecting the data is the next step to select an O/D pair and route. The results from determining the unique cost characteristics of the route and calculating those costs will result in generated cost and revenue data. From there, a model is selected to best analyze that generated data to answer the research question.

From Chapter 3, we have reviewed and identified various RU typologies and prospectively selected service models **1, 4 and 5**, as well as RU operating models. In Chapter 4, we will establish a method to analyze O/D pair sets with traffic characteristics of commodity composition and volume that conform to the selection criteria of cargo that has the highest probability of being transported in containers or truck trailers. The overall method is to first extract meaningful empirical data from pedigreed sources and secondly, to develop a model to use the data as input to assess financial performance, the results of which are the model's output.

The model to use will be a cost simulation model, with the broad goal of profit maximization. The original approach specified a general engineering orientation. However, after review, the model was amended to a hybrid cost calculation model, combining an activity-based approach, predicated on realistic operational events depicted in various combinations of operational scenarios or "cases". The model is intended to be viewed from the perspective of the RU or train operator.

This makes sense because the entire spectrum of operational elements consists of a series of events with costs associated with the RU's execution of transportation service activities. Aside from fixed costs, transportation costs are largely driven by production activities e.g., operations, shifting the model approach to one that is more based on measuring the cost of activities involved in conducting transportation.

Once transportation costs are known, adequate profit margins can be added after the total costs are calculated to arrive at pricing to know if providing the transportation service is remunerative and competitive, relative to the pricing of competing movements of similar loading units by trucks.

A motivation for using this approach is the paucity of recent and sufficiently disaggregated commodity and volume data and the need to work backwards from a cost approach to a highly granular compilation of costs, driving profitable pricing and hence, maximizing profitability. The cost calculation model is designed for not only evaluating the eight selected cases in **Section 5.3 Choices of O/D Pairs**, but also has been designed as an analysis template for further research, adding different routes, types of rolling stock and addition of the trucking mode to evaluate the financial performance of a multimodal and/or multi-commodity equipment route choices.

This will establish a framework to identify candidate corridors, examine the traffic composition and volume of those corridors, operational practicality, establish a methodology rationale and build a cost model to apply answering the research question from Chapter One. In this chapter, we will establish the approach, basis and characteristics of the models considered and describe the process to select corridors of maximum profit potential through volumes of targeted cargo from the candidates identified.

Engineering and Activity-Based Approach

Some structure is necessary for this model. The first is to establish a methodological framework to determine costs and revenues for selected O/D pairs. The combined engineering and activity-based approach requires a detailed compilation of cost elements detailed further in this chapter.

4.1 The Candidate Models

With the tasks of compiling the necessary costs, commodities and volume data completed and now available, using more abstract and indirect model approaches would result in too much of a macro view of the costs, rather than on the detailed level required to realize the goal of determining profit maximization.

In **Chapter 2 – Literature Review**, there is a discussion of different costing approaches for railway accounting, as referenced by the Tawfik et al., contribution in ***"Brain Trains – SWOT Analysis"***. The two approaches mentioned were top-down and bottom-up methods. The "top-down" method, which uses average costs, is less precise than the "bottom-up" method and does not consider varying local conditions, operational characteristics of the railway line or other factors. The top-down method is typically used in traditional cost accounting systems and is not applicable to this research. The bottom-up method is much more applicable to this research, as it does consider varying local conditions, operational characteristics of the railway line or other factors. In summary, the bottom-up considers marginal costs and the top-down considers average costs.

A brief review of common models summarizes why the approaches below are not the appropriate tools.

Multinomial logit model (or binomial logit, since there are only two modes to select from – rail or road), is an aggregate model using time series data (where the objective is to derive average values explaining the behavior of a group and is probabilistic in character). With multinomial logit models the decision maker's choice is rooted in *"As long as the choice of the individual is established in random circumstances that never occur identically, the modeling will be probabilistic"*[43]. Another property of this variation of the choice model is that the probability of an actor selecting a choice of modes could be affected by unknown attributes or characteristics that would skew the utility of other alternative modal choices. For example, in the case of a decision maker in selecting a transport mode, the multinomial logit model does not consider variations in the motivation of individuals selecting the mode, with respect to unobserved (or unaccounted for) characteristics that may emerge during surveys. An example of this is the ease of booking cargo transportation by mode. Some logistic software packages do not include details that are unique to rail and thus make it difficult for decision makers to either book directly or develop workarounds that ameliorate the deficiencies. This would affect choice probabilities for that mode. [44]

- This is not the environment under which an actor (RU and/or investor), would base a decision. A rational decision choice would be made by analyzing the data generated by the cost simulation model, which is not a probabilistic process. Therefore, the model is not applicable to this research.

- Discrete choice models are more suited to analyzing and predicting random decision behavior of an actor making a choice, based on their perception of the utility of the choices, as well as the characteristics of the actors themselves.[45] With the discrete choice model, the objective functions of the decision maker will want to optimize are in with a relatively unstable (not fixed), and more random environment, in which the variables are unstable enough to not be reproducible on a consistent basis. Given the randomness of the inputs, the calculation is thus more rooted in probability that an actor will make a certain decision, given the array of choices in each environment at the time of decision. [46] It is important to recognize that discrete choice models are used to

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[43] Aloulou, Foued, ***"The Application of Discrete Choice Models in Transport"***, Submitted: December 6th, 2017, Reviewed: February 6th, 2018Published: November 5th, 2018, page 88.
[44] Koppelman, Frank S. and Bhat, Chandra, ***"A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models"***, US Department of Transportation, Federal Transit Administration, (2006), Page 223 – 224.
[45] Limbourg, Sabine and Tawfik, Christine**, *"Bilevel Optimization in the Context of Intermodal Pricing: State of Art",*** Conference Paper in Transportation Research Procedia, July 2015, P.8 Paragraph 5.
[46] Ben-Akiva, Moshe et al., ***"Discrete Choice Analysis of Shippers' Preferences"*** in Freight Transport Modeling, Published online: 15 Feb 2015; 119-141.

also analyze the *behavior* of decision makers. The approach of the blended engineering and cost simulation model is microeconomic in nature, in which the array of variable choices is defined, stable and transparent. Given the fixed parameters means that the decision maker (the RU and/or investor), decisions are rational, with respect to the objective function, which is maximizing profit. The data needed by the decision maker, as to what case scenarios to pursue are based on the analysis of data that is self-generated through the cost simulation model, whereas *"These models calculate, from* ***given observations****, the probability that an individual selects a particular mode of transportation from a set of possible and mutually exclusive choices"*[47] Therefore, the family of models is not applicable to this research.

- Models whose approaches involve spatial distribution of transport flows, distribution of activities and assignment to vehicles do not address the objective and also are aggregate models that use only NUTS2 levels of aggregation to define freight flows (NUTS2 only defines regions at a sub-national level, which is too coarse and does not meet the data requirements for this research.

- Multilinear regression models and variations (Lasso and Ridge regression) would not be appropriate, because the data from the cost simulation model data is self-simulated.

Many models, including the models listed above and their variations are too much at an aggregate level for this research. They do not offer insights into the underlying costs on a microlevel. The overall purpose of the detailed cost analysis is to identify cost elements more precisely and help RU's find ways to reduce costs and thus help maximize profitability. This, in turn, enhances the ability of an RU to offer more competitive pricing, through "micromarketing" to transport decision makers, who comprise the underlying demand.

Elements of the rail cost simulation models discussed further in the literature review have some application to the general basis of the combination cost simulation model adopted for this research.

The "***Great Britain Freight Model – GBFM"***, **MDS Transmodal (2008),** covered in **Section 2.6.3.1** was interesting because the O/D pair selection analysis, used commodity and volume data down to the NUTS3 level for parts of the model, which is important, because it gives

[47] Aloulou, Foued, ***"The Application of Discrete Choice Models in Transport"***, Submitted: December 6th, 2017, Reviewed: February 6th, 2018Published: November 5th, 2018, page 87.

greater resolution to the nature of the traffic, than higher levels of geographic units, such as NUTS2.

The costing model described in ***"Activity-Based Rail Freight Costing"***, **Troche (2009)**, discussed above in **Section 2.6.3.6** coincided closest to the combination approach ultimately selected for this research.

The approach of the IWT models discussed earlier in **Sections 2.6.4.1** "***Developing a Cost Calculation Model for Inland Navigation"***, **Al Enezy et al. (2017)**, and **2.6.4.2** ***"Structuring and Modelling Decision Making in the Inland Navigation Sector"***, **Beelen (2011)**, were also of interest, because they coincided with and validated the combination methodology selected for this research.

In the end, the combination approach selected differs from more macro-oriented models, in that it will have the characteristics of both an engineering and activity-based simulation model. The engineering-based aspect of the model is for the purpose of cost simulation, in which the detailed cost structure will include data elements that would be universally common to the cost structure of a transportation enterprise oriented towards cargo traffic, having either or both an intermodal and traditional rail traffic base, as well as those costs unique to the selected routes, which will be integrated formulaically, as described further.

Therefore, for the goal of generating data to analyze and compare case scenarios, the methodology selected is to develop a cost simulation tool, as a cost model, initially with an engineering and activity basis.

4.1.1 Cost Calculation Model Details

Developing a simulation cost calculation model requires identifying and differentiating between the varying cost elements, described in further detail in the following sections.

4.1.2 Differing Costs for Route Segment Path Costs.

The route segments along the corridor will have different costs from each other and will vary by the O/D combinations. It is possible that one RU and its affiliates may handle the train along the entire route, but an equally likely scenario that multiple RUs will operate the train along their respective segments along the corridor. Originally, the intention was to average all costs along the corridor route. Regardless of if there are independent RUs or one larger and integrated RU that conducts train operations, under some conditions, the costs were to be blended to arrive at an average total cost for a specific cost element of operation, to avoid ferreting out each cost element in exhaustive detail. This approach proved not to be as useful to answer the research question, because of the routing variations and cross-border interoperability, as described further.

In later iterations of the cost analysis process, tools were discovered to determine path costs more precisely for each country's route along the corridor selected, depending on the O/D pair. Those tools are explained in more detail in **Chapter Five – Empirical Use of the Cost Model** section.

4.1.3 Differing Costs for Sub-Network Route Segment Path Costs

Another variable is the selection of sub-network routes *within each country*, which are not always the most direct paths between points. Often, the paths are governed by the classes of track, with respect to tons per axle, train length limits and line characteristics, such as length of sidings, total train tonnages (which can affect passenger train operations, through freight train performance characteristics), or even whether a line segment is electrified or not.

4.1.4 Differing Costs for Route Segment Energy Costs.

Other examples of differing costs over route segment are energy costs. Each network operator publishes a base energy cost per kWh, but the actual cost can vary by day (holiday or normal working day), time (peak demand during the day vs. off-peak night rates), region, how energy is generated (renewable, nuclear or fossil fuels) and other factors. In this case, energy costs must be averaged per kWh for the country of the network and/or as defined by their respective network statements.

4.1.5 Ancillary Charges from Network Authorities.

Network reservations also carry charges, which are nominal, if made far enough in advance, but costly if the path is needed on a short-term basis.

4.1.6 Train Handling at Border Crossings.

How trains are handled at the border and the costs for changing locomotives and the time spent doing so are also chargeable events. As an example, the cost for changing a locomotive in either direction between Germany and Poland is approximately €300, at the time of this writing. (Source: Rail Polska Z.o.o.). Between Germany and Netherlands, in each direction, the cost is €500.

4.1.7 Train Length and Weight.

The length and weight of the train over a route segment is governed by the most restrictive operational constraints along the network path(s) from origin to destination, which in turn, will determine the maximum number of wagons in the train. A realistic mix of loading units will determine the types of wagons and their likely costs and revenue per loading unit. The combination of all loading units and wagons will also help determine a conservative assessment of revenue attained, which are standardized to T-3000 pocket wagons and 40-45 ft. trailers or 40 ft. ISO containers in this research.

4.1.8 Pre and Post Handling Costs.

Costs are applied to each of the beginning and ending corridor segments of the O/D pairs selected, to compile costs of "Pre and Post Handling" (PPH), assuming combined transport (CT) and arriving at a cost basis per loading unit. In general, the freight forwarder or trucking firm embeds this in their cost of transport to the customer and is not compiled in the model. [48]

4.1.9 Locomotive and Wagon Costs.

Due to the high initial capital costs of rolling stock, the cost model assumes that the locomotives and wagons will be leased and not owned outright by the RU's.

Costing data will draw from a compilation of the individual cost elements that comprise rail operations on as granular a level as possible. This will entail examining potential operations in a range of EU countries, consistent with the candidate corridors being contemplated. Those elements of cost are identified and categorized in greater detail in **Section 4.2 Granular Costing Elements of the Costing Model**.

4.2 Granular Costing Elements of the Costing Model

The elements to be included in the costing model are detailed next.

4.2.1 Fixed Direct Costs

1. **Locomotive rental (LR)**

   Locomotive rentals, as relating to fixed direct costs are long term transactions and have two basic forms:

- All maintenance costs included, sometimes referred to as a "wet" lease. This is often used by RUs that do not have permanent locomotive maintenance infrastructure, personnel, nor have the administrative status of "vehicle keepers" within the EU. These

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[48] As applied to this research, the intended customers of the RUs depicted in the simulation model are CT transport cooperatives, trucking and forwarding companies. As such, the model will adopt ***"Real Cost Reduction of Door-to-Door Intermodal Transport (RECORDIT)"*** *(2001),* research methodology stated as ***"Combined transport co-operatives formed by trucking and forwarding companies (Kombiverkehr, CTL, Novatrans, Trailstar,), with a European association UIRR, provide competition for the national rail companies in a wide range of markets by offering door to door services. Focusing mainly on swap body, trailer and Rolling Highway movements between terminals, they tend to leave the arrangement of pre-/end haul together with shipper contact to forwarders and hauliers. Most UIRR-companies restrict their activities to their national borders and co-operate with their UIRR neighbour."*** Page 116.

costs are quite high, but relieve the RU of the administrative and regulatory burdens and regular maintenance and upkeep responsibilities. Many, if not most RUs choose this model.

- No maintenance costs included, sometimes referred to as a "dry" lease. Those RUs and/or large, integrated companies who have scale, maintenance infrastructure, the appropriate personnel with the specialized skills for maintaining the leased locomotives, the administrative resources for regulatory requirements and/or large balance sheets opt for this model.

- A "spot" lease or combination of the above models. This will be covered in the variable costs section in more detail.

2. Wagon rental (WR)

Wagon rentals, as relating to fixed direct costs are long term transactions and have two basic forms:

- "All maintenance costs included" model. This is often used by RUs that do not have permanent wagon maintenance infrastructure, personnel, nor have the administrative status of "vehicle keepers" within the EU. These costs are quite high, but relieve the RU of the administrative and regulatory burdens and regular maintenance and upkeep responsibilities. Many RUs choose this model.

- "No maintenance costs included" model. Those RUs and/or large, integrated companies who have scale, especially maintenance infrastructure (workshops), the appropriate personnel with the specialized skills for maintaining the leased wagons, the administrative resources for regulatory requirements and/or large balance sheets opt for this model.

- A "spot" lease or combination of the above models. This will be covered in the variable costs section in more detail.

3. Insurance cost (INSC)

As regards locomotives and rolling stock, this fixed cost is usually expressed as a percentage of the value of the equipment. As a general rule, the formula of 1.5% of the value of the rolling stock is applied as a fixed cost. Other insurance costs, covering general liability, cargo and railway operational liability is handled formulaically as an insurance premium, based on a composite estimate of 2.0 % of turnover.

4.2.2 Fixed Indirect Costs

4. **Sales, general and administrative ("SG&A")**

   These non-operating costs relate to the administrative infrastructure of an RU organization. Such categories included in the cost model are administrative personnel and their social costs, professional fees, rent, utilities, insurance, sales and marketing efforts, office supplies, miscellaneous non-operating related costs and the like.

5. **Depreciation of fixed assets, other than rolling stock (DFA), (only if equipment is owned)**

   This category is for workshops, office building, terminals, yards and any other capital asset necessary for operations. This category would include rolling stock for this research because the equipment would be spot-leased and thus not be eligible for this deduction.

4.2.3 Variable Costs

TTT = Total Transit (or Train) Time

6. **Personnel, operating - time over line segments (Labor cost, operating per hour – LCOH)**

   This is expressed as a per hour cost for operating personnel, depending on the specific territory of operations. For the operating labor categories, there are the following:

- Locomotive drivers
- Helpers (ground men – coupling, uncoupling lacing air hoses, MU couplings, remote control devices, air tests, minor running maintenance, as required)

7. **Subcontractors, operating (SO)**

   It is possible that operating contractors, such as drivers, helpers and terminal personnel are required for peak periods or even as substitutes for regular personnel, especially if the traffic is sporadic and not predictable. There are enterprises around Europe that specialize in supplying trained personnel for operations for this reason and because it is expensive to maintain overhead for irregular traffic.

8. **Energy costs (diesel fuel or kW consumed) (EC)**

   This is expressed as kWh consumed for the line segments within each country that the train operates over. Infrastructure managers of each country's system publish a "network statement" that includes the € per kWh, which is in the costing model reference table for each territory the route traverses. If the locomotives are diesel traction, the reference table will have the estimated liters per km, sourced from technical documentation on various types of locomotives. Often, electric energy costs can vary by the time of day and day of the week. Night operations are almost always most economical. In the costing model, an average cost is determined by running a multiple number of scenarios over a route and taking a composite energy cost from sources such as ***Trassenfinder.de***, DB Netz's infrastructure cost calculator. These are the values that have been entered into the model's energy cost reference tables.

9. Infrastructure costs (slots or paths) (IC)

Infrastructure managers of each network publish a network statement that includes the cost per km, which is in the costing model reference table for each territory the route traverses. The values are expressed as €/km.

10. Equipment costs

a. Container rental (if on a "spot" basis) (CR)

There is a provision in the model for this value for future use and expansion of capabilities, although it is not used for this research, as the customers are providing the loading units.

b. Wagon rental (if on a "spot" basis) (WRS)

i. running maintenance (brake blocks, air hoses, etc.) (WSM)

The nature of the leasing market has changed through migrating to more flexible leases. The traditional model, described in the fixed direct cost section on leasing is still operative, but due to the high cost and risk of a long-term equipment lease commitment for traffic that may not materialize or could vanish for various reasons, RUs have been reluctant to commit to that form of lease. In its place is a variation of a spot lease (short term) and something more intermediate term, such as 6 months to a year. In the past, a prospective customer would be required by the operator to commit to lease the equipment for at least a year and more probably, two years. Customers, not knowing how rail service would work out for them, were understandably reluctant to make such a large financial commitment and consequently opted for truck. In the double objective of the general effort to win back business and promote a cargo shift to rail, some lessors have chosen to be more flexible in their terms, with good results. Based on inquiries to leasing companies, it was possible to get leasing cost information. This forms the basis of the lease cost data in the model's reference tables. As regards running maintenance, often, lessors require small repairs, such as brake blocks, air hoses, etc. to be made by the lessees, which is more practical than taking a wagon out of service for something as simple as brake blocks and hoses, plus the cost and time required to move the wagon(s) to and from a designated maintenance facility.

c. Locomotive rental (if on a "spot" basis) (LRS)

i. running maintenance (brake blocks, air hoses, lube oil, etc.) (LRSM)

Locomotive leases follow the identical model, as described above. That data represents the basis of costs in the model's reference tables for locomotives and was obtained from locomotive lessors and general knowledge of the marketplace.

11. Terminal costs (TC)

In general, the RU operations depicted in the model do not include these costs, because the shipper (freight forwarder and/or trucking company) is handling them through their first and last mile delivery costs to their customers. Nevertheless, there is a provision for these costs in the model's reference table and the cost per lift ranges from €20 to €50 per lift.

a. Lifts (tcl)
b. Storage (tcs)
c. Train shunting and handling (TSH)
d. Wagon shunting and handling (WSH)
e. Pre- and post-trip mechanical inspections (PPTMS)

These are costs that are handled as part of the duties of the operating personnel and are not separated in the costing model. Nevertheless, there is the capability to add this cost element later in the model.

12. Miscellaneous (MISC)

These represent unforeseen expenses on an incidental and one-off basis. An example of this would be a delayed train, due to circumstances out of the control of the operator. If the hours-of-service time were exceeded for the crew, they would have to be housed somewhere and fed. That cost would be recorded under the miscellaneous expenses category. In the model. This is an arbitrary amount of €1,500 per month for the first year and graduating by an inflation figure of 3% per annum per year for the next two years. This data is sourced by the model from an inflation value reference table.

The economic viability of freight rail service for an O/D pair, considering total revenue – total costs, will be expressed through three formulas:

An overview of the formulas is, as follows:

((Estimated Fixed Direct Costs) + (Estimated Fixed Indirect Costs) + (Estimated Variable Costs)) = Estimated Total Costs (per year)

((Estimated revenue per loading unit) * (loading units per wagon) * (number of wagons permitted per train) * (arbitrary load factor) * (Trains per week – RevTripWk * 50)) = Estimated revenue per year

((Estimated revenue per year) – (Estimated cost per year)) = Estimated Net revenue per year (Assumes min. 2 trains/week)

Estimated Total Costs/Estimated Net Revenue = Breakeven point factor

Spelled out:

Costs = (((Locomotive rental + (maintenance, direct + maintenance reserve) + (Wagon rental + (maintenance, direct + maintenance reserve)) + (Insurance) +) + ((SG&A) + (Depreciation, fixed assets)) / 50 trains per year) + ((Labor cost for train time operations per hour) + (energy costs) + (Infrastructure costs) + ((Terminal costs) + (Miscellaneous - contingency)) * (number of trains per week * 50 weeks)))

Formulaically:

Costs = (((LR + (LMD + LMR) + (WR + (WMD + WMR)) + (INS) + (IT) + (OBSS)) /TY + ((SG&A + DFA)/TY)) + (((LCHTTO + E + IN + TC + MISC)) * (TW *52)))

$$\text{Annual Cost} = S\left[\sum_i L_i + \sum_i W_i + I + A + T_y\left(\mathrm{O} + \mathrm{E} + \sum_p C_p + \sum_t C_t + \mathrm{C}_m\right)\right]$$

Equation 1: Cost Formula

$$\text{for } \mathrm{i} \in \{\text{rental, direct ("running") maintenance, periodic maintenance, reserve maintenance}\}, \mathrm{p} \in \{\text{countries covered by route}\}, \mathrm{t} \in \{\text{terminals included in route}\}$$

$$\text{and } C_t == l_t + st_t + tsh_t + wsh_t + pptms_t$$

where:

Fixed Direct Costs	
Number of Train Sets	S
Loco rental	L_R
Loco maintenance, direct	L_{MD}
Loco maintenance, reserve	L_{MR}
Wagon rental	W_R
Wagon maintenance direct	W_{MD}
Wagon maintenance reserve	W_{MR}
Insurance	I
Fixed indirect costs	
Sales, general & administrative	A
Variable Costs	VC
Trainset Trips per year	T_y
Labor cost per hour, train trip operations	O
Energy costs (kW or diesel fuel)	E
Path (or Infrastructure) costs, by country	Cp
Miscellaneous	C_m
Terminal costs (per terminal, t)	C_t
Lifts	l
Storage	st
Train shunting & handling	tsh
Wagon shunting & handling	wsh
Pre and post trip mechanical inspections	pptms

With the model cost elements now established and defined in granular detail, the next steps are to identify the underlying data needs and a rational structure for use, the process of which begins in the next section.

4.3 Data Needs and Structure

This section discusses the various data sources, process methodologies, data issues and workarounds to analyze data for this research using EU data. Data for freight flows falls into two broad categories:

- Aggregate
- Disaggregate

To measure freight flows and to test the costing model for this research, the following base-line information is required:

- Kilometers between points for O/D territories selected

- Time between points for O/D territories selected

- Tons moved between O/D territories selected

- Commodities, disaggregated by NST/R 24 level in Europe and, if possible, to the NST2 level, as the commodities are disaggregated on a more granular level (NST2007 is newer data, but the commodities are grouped by production processes, rather than the more descriptive categories needed from NST2).

- Geographic regions within the continent of Europe, defined as the EU states, with extensions to the non-EU Balkan states on a minimum of a NUTS2 and preferably on a NUTS3 level, if available

In general, simple aggregate freight flow data is rather readily available from numerous sources, such as EuroStat, the European Union's statistical offices. The disaggregated freight flow data is more challenging. In this section, the sources, uses, the characteristics of and limitations of available data will be explored.

4.3.1 EU Data Sources - Public

Considerable effort was expended into developing public sources for data, as the private sources were not available without payment. Below is what was explored. For Europe, some primary categories needed for raw freight flow data flow, by commodity, are:

i. Trade by mode (Eurostat – COMEXT) – value, tons
ii. UN trade data (COMTRADE) – value, tons
iii. International road freight – tons
iv. Domestic road freight – tons
v. International rail freight – tons
vi. Intra-country rail freight – tons
vii. International maritime freight – tons

The above categories can be extracted from EuroStat, albeit in mostly aggregated form. Possible data sources to access for both aggregated and disaggregated traffic data include the following, as applied to conversion process of freight flows into containerization, in the context of gauging the potential of shifting truck volume to rail:

- **The European Commission**, to promote its policies, has established a "*Scientific Support to Policies*" project to "*improve modeling of freight flows between Europe and the rest of the world*". The broad objective of the project is to contribute data to a European transport network model, known as "Trans-Tools". Expanding the amount of data available for the Trans-Tools model to use will expand its utility and general use by researchers and policy makers.

  The Core TRANS-TOOLS freight model uses the following inputs:
  - Port-related tonnages by product
  - Maritime freight flows

  Further detailed data are sourced from:

  - ETISplus Data Extensions - (2009-2012, DG-MOVE, FP7)

    This data comes from Eurostat in the form of trade data called COMEXT, which consists of EU27 trade data and Extra-EU trade data. COMTRADE data is also used and consists of trade data from non-EU countries.

    The data inputs listed above are combined to arrive at a certain monetary value of trade, which is then converted into weights. Those weights of the categories of cargo would be aggregated, with the heavy bulk, low value and non-time-sensitive cargo assumed to be assigned to rail transport bound for destinations not served by inland waterways or other ports with short sea shipping service available. The Extra-EU data offers modal information, as well as estimated containerization levels. According to the document:

    Containerization factors vary by:

    - Product group
    - European market
    - Overseas market, and
    - Time period

    The factors listed above help convert into containerization at varying rates, which represents the conversion into TEU.

    The maritime transport data source is called NEWCRONOS and includes three categories:

    - Maritime freight handled by port and type of goods.
    - Maritime passengers by port

• Vessel arrivals by port

According to the document: *"The main limitation of these data sources is that they do not connect the port volumes, either by mode of transport or by region of origin/destination to the hinterland. Therefore, modeling steps are needed to provide this connection"*. Source: 2010 - 12 – Ports and Their Connections within the Ten-T

- **The Port of Rotterdam** originally, as of 2016, the statistics portion of their website was useful, as it tracked:

  - Goods grouped by commodity,
  - Goods grouped by origin and destination
  - Containers and TEU's Time Series
  - Modal split for maritime containers
  - TEU's grouped by origin and destination, incoming and outgoing
  - Container data, as to incoming and outgoing, by classes of length and TEU (<25 ft., 30 – 30 ft, 40 – 44 ft and 45+ ft.)

However, as was similarly discovered with Eurostat in the search for more recent and disaggregated data to support this research, this level of detail is no longer available.

Determining the prospects of increasing modal share by rail is not a straightforward endeavor and will require considerable work. Modeling, with proper data inputs, will help provide a perspective through *inferred* traffic. However, the data limitations and availability will require substantial work-around methodologies to arrive at usable information.

Empirical data from the actual integrated companies and operators, of course, would be optimal, but it is also realistic to assume that much of this data is proprietary and unavailable to researchers.

Therefore, combinations of the above data sources of cargo are to be blended into their respective categories, to the degree possible, for validation and calibration to arrive at meaningful results.

4.3.2 Private Data Sources

There are various private sources in Europe for derived disaggregated data, such as:

- Decision Support and Management Information Systems (DEMIS) BV of Delft NL
- Ecorys – Rotterdam NL
- Panteia BV of Zoetermeer NL

These are research-based consultancies quite capable of developing and analyzing data that would be the foundation of this research, but at a high cost.

- **MDS Transmodal**, a UK consulting firm offers forecasting based on a proprietary model and data with O/D by country and down to a commodity level. The company cooperates with the UK-based "Rail Freight Group" and the "Freight Transport Association" for industry data, which is the input for their model. Databases and models were developed in-house. The following is a partial listing of relevant databases:

  - MDST World Cargo Database, which is a trade database of trade statistics of all countries and 3,000 commodities down to the SITC 5-digit level, from the period 1996 to current quarters

  - MDST European Region-to-Region Trade Database with trade flows between regions of European countries and updated annually

  - Container Line and Port Modeling transport cost model uses data accumulated over years of consultancy by the firm. The relevant portion of this relates to bulk trading, with origin and destination data

  Source: *"Capability Statement - Ports and Shipping"*, November (2013), MDS Transmodal

4.3.3 Other Data Sources

4.3.3.1 RETRACK Data

Through earlier work and the discovery of studies done at the ***Karlsruher Institut für Technologie (KIT)*** in Karlsruhe, Germany, a useful source was found. This study focused on finding ways to facilitate freight modal shift favoring rail, with the participation of Professor Kay Mitusch, one of the authors of the research, along with cooperation from two highly respected the private research organizations:

- Panteia BV of Zoetermeer Netherlands
- Decision Support and Management Information Systems (DEMIS) BV of Delft Netherlands

Their research was called the "**RETRACK**" study, an acronym that stands for *"**RE**organisation of **T**ransport Networks by Advanced **RA**il freight **C**oncepts",* which was started in 2007 and ran until 2011. The description of that study is:

"The RETRACK project aims to contribute to the Commission's aspirations of a modal shift of freight traffic from road to rail with a market share of 15% by 2020 to achieve commercial viability and contribute to sustainable mobility. This aspiration is also supported by the

European Rail Research Advisory Council's (ERRAC) declared aim of bolstering rail's market share of freight to a similar level.

The project developed the Corridor Knowledge Base (KB) System for rail freight corridors in Europe. It enables presenting multiple corridor studies, each corridor with its own Knowledge Base site on a separate tab. The Corridor KB system includes the Retrack and REORIENT corridors and allows easy expansion with other corridor studies. The KB site contains document libraries and data that are relevant to the Retrack corridor. The data is presented through online tools for viewing / editing of multi-dimensional data tables and GIS network data with rail links and terminal nodes."
Source: *Demis* web site https://www.demis.nl/projects/etna-plus/

The data obtained from the **RETRACK** project lends itself well to this research. The data output is in the form of O/D matrices and available on a NUTS3 level. The source data is provided from 2010, as a reference year and based on the 2006 NUTS definitions for EU countries. For territories within the EU, the NUTS2 and NUTS3 zoning system is merged with territories outside of the EU in equivalent terms, referred to as Level2 and Level3, but both systems are functionally the same and the derived level of disaggregation lends itself well to this research.

This data is particularly valuable, because it is no longer available from EuroStat, especially at those levels of disaggregation.

The tables include the following data structure and elements:

- O/D data disaggregated at a NUTS3 level

  According to the European Commission (EC), this classification of data has three levels with the following definitions:

- NUTS1 – Major social-economic regions, such as countries
- NUTS2 – Basic Regions, such as states within a country
- NUTS3 – Small regions for specific analyses. These would be equivalent to counties in the US

  The NUTS3 data described earlier is disaggregated down a merged zoning system down to a nine-digit level for micro-level analyses of commodity volume between the nine-digit level geographic units.

- O/D data disaggregated by commodity using NST/R Level 2

Initial NST/R data (up to and including reference year 2007), will be based upon 24 groups following the ***"Standard Goods Classification for Transport Statistics/Revised (NST/R)"***. However, in 2008, the basis for the NST/R changed from being based on physical attributes of commodities to being related to the base production processes forming the nature of the goods. The data obtained above includes commodities based on NST/R 24 and as newer data becomes available that includes commodities described under that NTS/R 2007 scheme, that data structure will then be explored, as to whether it is sufficiently disaggregated.

The commodity volume is expressed in tons between O/D pairs. Also, there are "impedance" reference tables, which include both kilometers and time between O/D pairs for trucks and kilometers for rail. The table structures can be referenced in Appendix Section B.

4.3.3.2 Network Managers (Infrastructure) Data Sources

A substantial part of operating costs comes from path charges from the respective countries' network managers, which are available either from **RNE/CIS**, the European clearinghouse for network paths and costing, based in Vienna.[49] In the case of Germany, through which all the test cases traverse, use of DB Netz's ***Trassenfinder.de*** website is a data source. This website offers useful details of routing, path costs, time elapsed (for crew costing) and kWh consumed over the path, based on the choices of locomotives for traction and the train consist composition of wagons and weight. Train length, wagon weight, total load weight are parameters considered in the calculation of path costs, transit times and, in the case of DB Netz, the energy consumption, with costs known on a more detailed basis, the data offered helps in costing each operational case. Energy costs are thus more easily determined by applying a kWh cost per kilometer interpolated to other countries that do not offer that detail.

4.3.3.3 Delphi Sources

These sources have proven valuable in identifying hidden and idiosyncratic charges associated with operations that otherwise would have been overlooked. Examples of this are discovering an increase in allowable train length in Poland by 30 meters (630 vs 600 meters) train length over some routes, a cost of €300 to change locomotives on the Polish German border and €500 for locomotive charges between the German and Netherlands border, if there is a subcontractor handling "one-off" spot services for safety organization representation. (If there are regularly scheduled services, this cost disappears). Another example is the routing of trains

[49] Deriving network and energy data from the RNE/CES system has proven a challenge, though efforts were ongoing to use the system. On 24 June 2022, the latest communication from RNE/CNE was as follows: ***"Creating the CIS application on the European level is very complex work and we still don't have data for some crucial countries, such as France (SNCF), please avoid using France. Application work partially and could not be taken as a plausible one for the next time. We are still in process of collecting all essential information (data, formula, routing,) to make it much more accurate as possible."***

from Germany to the Port of Rotterdam and the necessity to stop at a shunting yard first (Kijfhoek), and from there, the Havenroute starts and where the other inbound and outbound lines connect to the port, as well. Without those insights, the model would miscalculate costs and profitability. The availability of cultivated Delphi resource relationships facilitated the exchange of operational, marketing and cost nuances that might not otherwise have yielded the detailed perspective necessary to construct a costing model with the granularity it contains. While Western or Southern European routes might have similar qualifying characteristics, the Delphi relationships did not exist.

4.3.4 Data Limitations with Respect to Ports and Container Traffic

With respect to the traffic volume oriented towards increased growth, e.g., container traffic, to derive the information required, one would need to know the loading units of transport, meaning what type of containers are being used. International traffic volume could be obtained from port throughput data, but this data is largely recorded as TEU's, with no breakdown, as to the types of containers.

Data limitations using international port traffic flow, with respect to containers, are:

1. **Origins and destinations** are not recorded
2. **Content of containers:** customs offices collect the data, but do not process it into a form that is usable or available to researchers. This means that if there is a migration of different types of cargo to containers from their previous method of transport, it is not tracked.
3. **Sector information:** some information is from a fragmented industry of transport service providers, e.g., freight forwarders, customs agents, integrated companies, steamship lines and land-based carriers, both rail and road
4. **Mixed cargo**: tracking mixed cargo in a container is not possible
5. **Efficiency of container utilization:** is the container optimally loaded?
6. **Is only one commodity carried in a container?** This is not known.
7. **Empty container movement** is not tracked.

As regards the origins, destinations and commodities hauled in containers between terminals (rail, intermodal or IWW) and maritime ports (due to customs not collecting data on traffic internal to the EU), the conundrum remains, as to how would one obtain the data necessary to help determine the research question, as ports are a critical origin and/or destination point.

However, these limitations have been overcome, since similar data has already been derived from research in the **RETRACK** program, in conjunction with the ***Karlsruher Institut für Technologie (KIT),*** as sources.

For this Ph.D., the data resources described in 4.3.3.1 RETRACK Data, 4.3.3.2 Network Managers (Infrastructure) Data Sources and 4.3.3.3, Delphi Sources were ultimately used.

4.4 The Method and Process Applied to Data and Empirical Work

The model will use a hybrid cost calculation model, combining an activity-based approach, requiring the type of data that helps determine total costs. The overall method is to extract relevant empirical data from the sources listed above and apply the cost calculation portion of the model to the expected operational activities driving costs, with the objective of minimizing costs and maximizing profit.

In actual practice, the process of data extraction was very lengthy and driven by the detailed needs of the hybrid model. This required multiple iterations of analysis to determine the precise elements of data needed for the model. Some of those data elements were results calculated from other data elements (fields) from different tables. Using Microsoft Access, tables were grouped by complementary data into separate data tables to be linked together with common data elements, such as origin and destination codes, NST2 (commodity) codes and filtered by tonnage values and O/D pair codes. From this core data, queries using SQL language were used to generate larger, combined tables that would be filtered to form the underlying tables needed for analysis.

With all the selected and filtered data elements now collected into combined tables using the process described above, the core data needed for the model was complete. The next step then required designing an Excel spreadsheet application to apply the costing elements to use the data, as pertaining to the defined candidate routes. The application was now in play to use the data generated from the tables of the now derived disaggregated data.

The steps of this entire process are detailed in **Appendix B** in **Sections B2 – B8**. The overview of how this now extracted and prepared data follows.

4.4.1 Process - First Step

The first step in the process is the selection of O/D pairs that will examine the flow of the type of commodities projected, given the characteristics of the network route candidates, as discussed above.

1. The cargo most likely to be shipped by rail, such as bulk commodities, chemicals, lumber, ore, paper, metals, mining products, etc. These offer the most common and stable traffic base and can serve as the primary traffic base, assuming the RU can secure this traffic from entrenched and incumbent RU's. (To be clear, bulk cargo will not be included in the analysis).

2. The cargo most likely to be shipped in a truck trailer or container to and from regions that generate balanced traffic (both directions).

4.4.2 Process – Second Step

The second step is the route selection process and will use the following data:

1. Disaggregate data, to the degree available, of traditional, secular commodities shipped in the corridor.

2. Disaggregate data of commodities of the type that would have the highest probability of being shipped in truck(s) trailers or containers. Often, these goods are cyclical and consumer-oriented, discretionary products.

3. The commodity flow, by tonnage between selected origins and destinations in a selected corridor on a NUTS 2 level and, if possible and if the data is qualified, on a NUTS 3 level.

4.4.3 Process – Third Step

The third step is the empirical work needed to extract the needed data elements from the following categories of data:

- Disaggregate transport data derived from ETIS-plus databases, per above
- Commodity flows, by tonnage, transported between likely O/D pairs in the defined corridor(s)

This was a most difficult step, as the data needed simply does not exist today at the level of disaggregation needed to assess the nature of the wide spectrum of traffic flowing between O/D pairs over the European continent.

Fortunately, this author was able to synthesize a representative set consisting of 3.7 mm O/D pairs for trucking and 488k O/D pairs for rail. (See more about this process in the Appendix).

With respect to costs, the model will use cost data compiled from both empirical data from the author's past archives, experience and knowledge and reality-checked against past costing data derived from selected studies listed in **Chapter 2 - Literature Review**.

4.5 Expected Model Outcomes

The outcome of the model is a calculated base of costs predicated on the activity generated by conducting the transportation of the estimated levels of selected traffic volume from the empirical data. The estimated traffic volumes are driven by the parameters of number of trainsets selected per week, weeks of operation per year, the number of wagons in a train and the number of loading units in each train (load factor). A range of transport rates per kilometer for €.70 to €1.20 in €.10 increments for each of the combination of traffic volume parameters is calculated to derive total revenue, minus total costs and determine profit or loss.

4.6 Flow Diagram

To synthesize what has been written in this chapter succinctly, the following is a written description of the flow diagram, illustrated by **Figure 7**, covering two pages.

4.6.1 First Iteration

Consider the defined corridor and add consumption (population), production and raw material source regions along route. Refer to **Figure 12** for a schematic map representation of the EU rail network. Determine population center locations.

4.6.2 Second Iteration

Determine largest volumes between points along the defined corridor, which are likely to be the largest consumption and production centers. Determine the largest volumes of commodities moving in both directions along this route.

4.6.3 Third Iteration

Determine volume and estimated costs from moving the cargo most likely to use rail. This helps determine frequency and establishing consistent frequencies, upon which freight forwarders and shippers can rely, means a recurring (and growing) traffic base.

4.6.4 Fourth Iteration

Assuming maximum train length, total tonnage for corridor profile and axle weight factors are not exceeded, use the excess capacity for addition of trailer and/or container traffic in the train. If train length limits, total tonnage or axle weights are exceeded, split train into two schedule frequencies or forego traffic of least profitability, until sufficient volume is realized to justify the addition of a separate train.

4.6.5 Fifth Iteration

From the empirical data, target commodities most likely to be containerized, finished and manufactured goods, plus food moving from southern regions along the corridor to Central

Europe, Germany and Nordic countries or food from higher cost to lower cost regions for processing.

4.6.6 Sixth Iteration

Determine likely cost of movement and shipment time required by truck, rail/intermodal along O/D pairs in this corridor, determine competitive costs and price competitively. Use model from REORIENT project.

4.6.7 Seventh Iteration

Determine modal share of the targeted commodities. Most likely, they travel by truck, unless they are bulk commodities, except possibly for high value chemicals in 30 ft. “tank-tainers”.

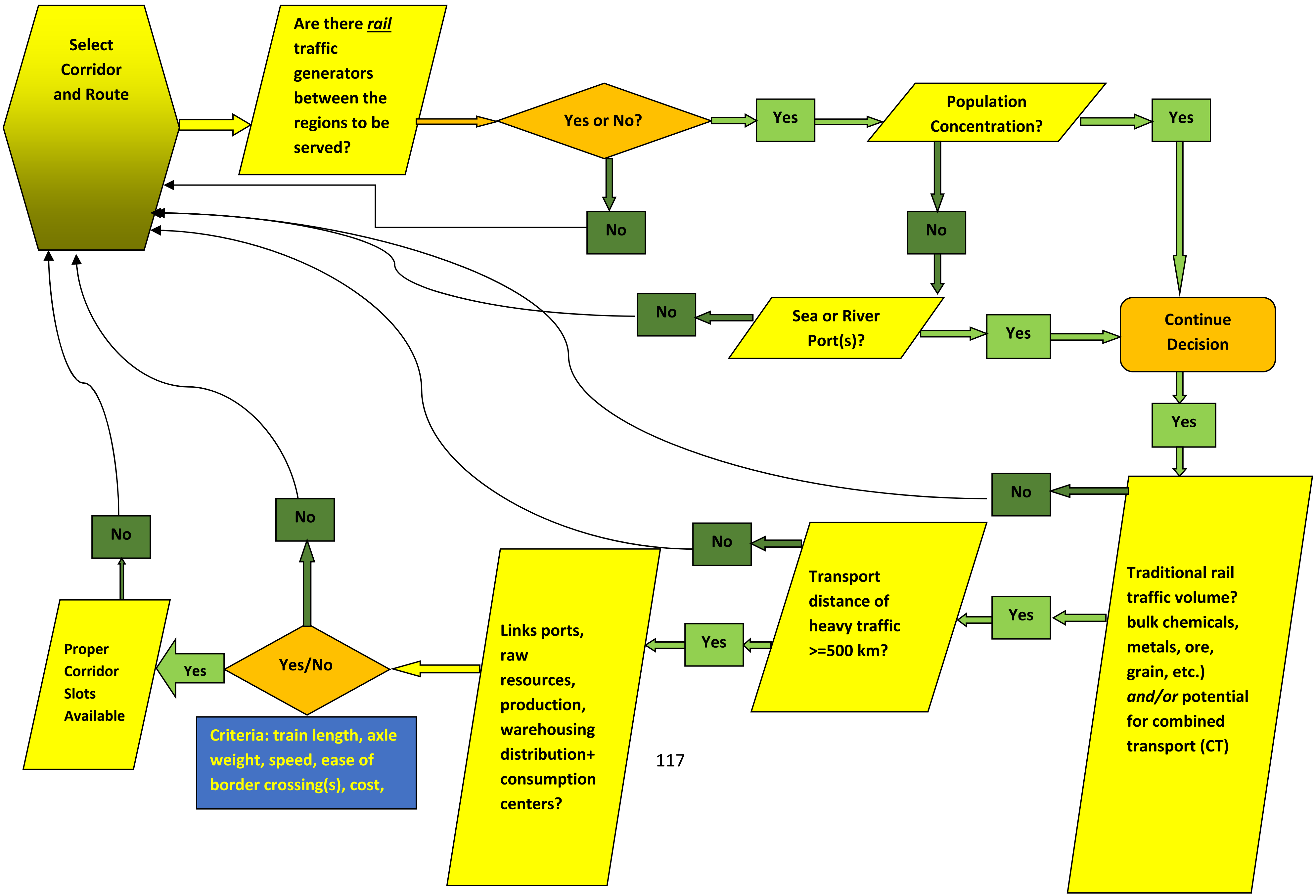
4.6.8 Eighth Iteration

Estimate the traffic volume of the commodities targeted and calculate the costs of moving that volume. After those costs are estimated, compare estimated revenue expected and compare against costs. As the goal is profit maximization, subtract costs from revenue to arrive at net profit (or loss).

4.6.9 Decision Tree and Flow Diagram

On the following pages are the graphically illustrated principals of the steps outlined above, along with the desired corridor and O/D pair attributes checklist as illustrated in **Table 7**.

Decision Tree for Selecting Corridor and Route – Part 1



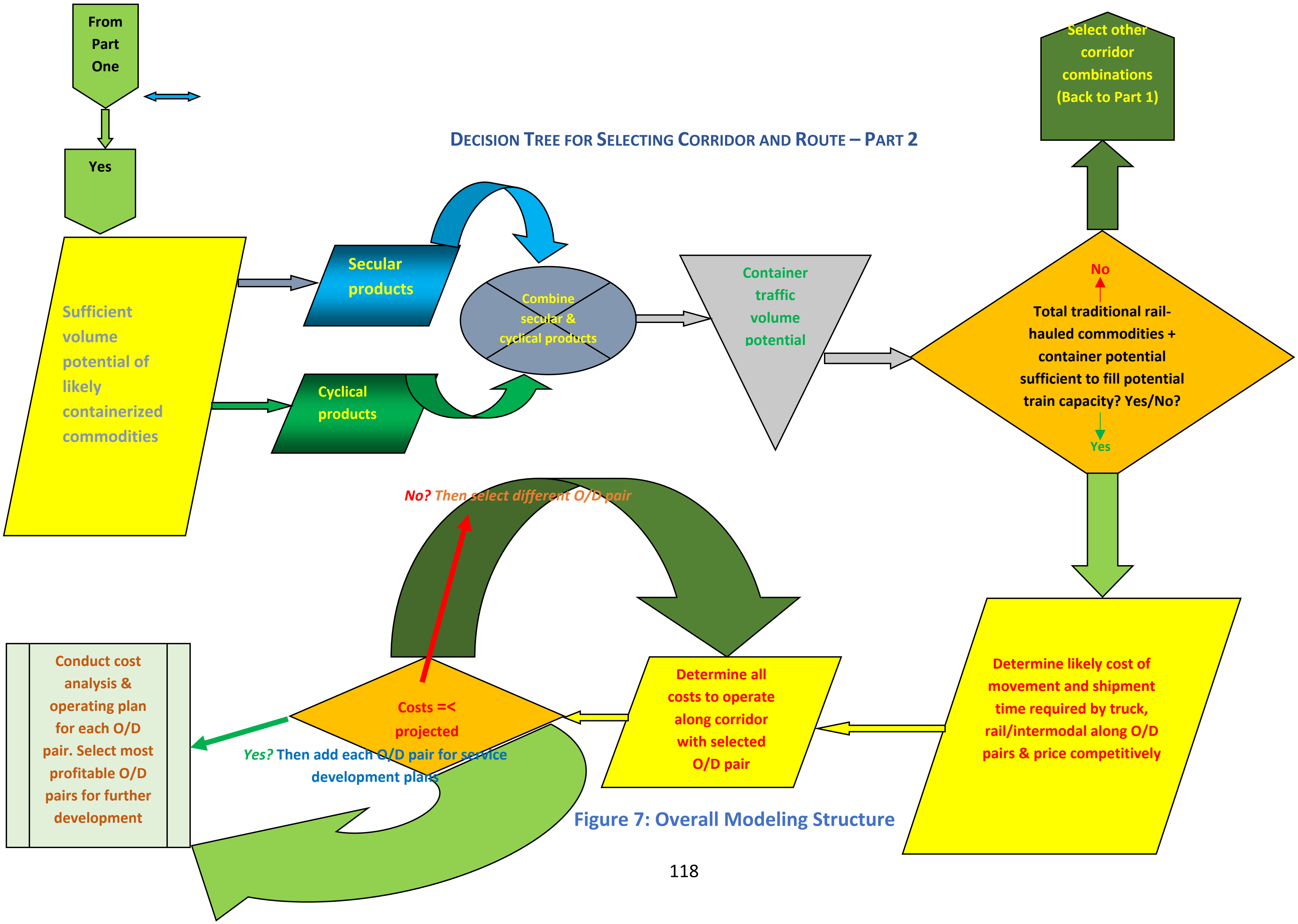


Figure 7: Overall Modeling Structure

Desired Corridor and O/D Pair Attributes Checklist - EU				
Name	Description	Corridor	Cities Served	Notes
Connectivity	Route using multi-corridor stations	Scand-Med	Oslo, Goteborg, Malmo, Copenhagen, Hamburg	Northern portion of route used, multiple connection points
Connectivity	Route using multi-corridor stations	North Sea - Baltic	Rotterdam, Antwerp, Hamburg, Berlin, Posnan, Wroclaw, Katowice, Warsaw	Most of corridor is used, multiple connection points
Traffic Generating Region	Operating in a region where there are traffic generators, hence traffic volume	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Multiple corridor connection points
Population	Population concentrations, not dispersed in a region	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Hamburg, Berlin, Posnan, Warsaw	Multiple corridor connection points
Transport Distances	Distances long enough between nodes to capitalize on rail's natural efficiencies	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Raw materials in north, finished goods in the south, DC's, multiple corridor connection points
Bridge Traffic Volume	Prospects of through (bridge) traffic volume (between regions and countries)	Scand-Med	Oslo, Goteborg, Malmo, Copenhagen, Hamburg	Denmark, in particular, is a good transit country, with good terminating traffic possibilities, Germany, as well.
Balanced Traffic	possibility of balanced traffic volumes in both directions	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Raw material, such as lumber, paper, limited steel and ore moving south and east, with finished goods, consumer durables, consumer goods packaged goods and food moving west and north.
Economic Clusters	Operating within and between economic clusters (complementary business subsectors concentrated in and between regions)	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Within and around large populated production areas, economic clusters of complementary enterprises emerge and add to transport activity.
Traffic Type 1	Container traffic to/from ports	Scand-Med	Oslo, Goteborg, Malmo, Copenhagen, Hamburg	Substantial container traffic to, from and between ports,

Traffic Type 2	Customers in stable sectors	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Rotterdam, Antwerp, Hamburg, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Traffic volume in stable sectors (secular vs. cyclical)
Traffic Type 3	Captive shippers and sectors	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Shippers who prefer to and/or must always ship by rail (low time sensitivity, lower value and/or bulk commodities), given the superior economics of rail, especially from Sweden and Poland
Service Models	Business and Service Models of Players	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Many combinations are possible, because the density of these corridors support many different complementary subsector players
Operating	Compatibility of Rolling Stock	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	Poor to fair, due to up to four different signaling systems and four different voltages and frequencies. Locomotive interoperability and issue. RU operating rules differences. Border operations, no problems
Line Characteristics	Physical characteristics of line	Scand-Med, North Sea-Baltic	Oslo, Goteborg, Malmo, Copenhagen, Hamburg, Rotterdam, Antwerp, Berlin, Posnan, Wroclaw, Katowice, Krakow, Warsaw	All corridors are well-maintained, high-speed, dense corridors with minimal limiting physical infrastructure, with respect to weight and dimensions of rolling stock. Also, grades and curvature are not severe. Most of the corridor route is electrified.
Regulatory	Homologation issues between countries	Scand-Med, North Sea-Baltic		Poor, as different locomotives must be used for Norway / Sweden, Denmark, Germany and Poland, unless the electric locomotives used have homologation in all these countries and the locomotives have signaling systems on-board that are compatible with all the countries, which is an expensive proposition.

Table 7: Desired Corridor and O/D Pair Attributes Checklist – EU

4.7 Flow Sources and Geographic Selection Criteria – Europe

Part of the methodology framework is to identify the likely sources of traffic volume. This means that criteria must be established to apply to geographic regions, as illustrated further in the flow chart shown in **Figure 7 – Overall Modeling Structure.**

The general principles of those criteria are to focus on regional concentrations of industrial and economic activity, as well as population clusters, which broadly comprise production and consumption areas. Most often, the regions have both characteristics and merit attention.

The following are illustrations of flow sources and geographic criteria selection focus on Europe, however the principles, analogue data sources and methodology framework apply to any region a researcher may wish to apply these resources. This data is quite useful and will be the model input for European traffic volume.

Integral to the research is selecting a country and/or region(s) and a corridor(s) that will link them. To set the context, we discuss the criteria used below, as applied to Europe.

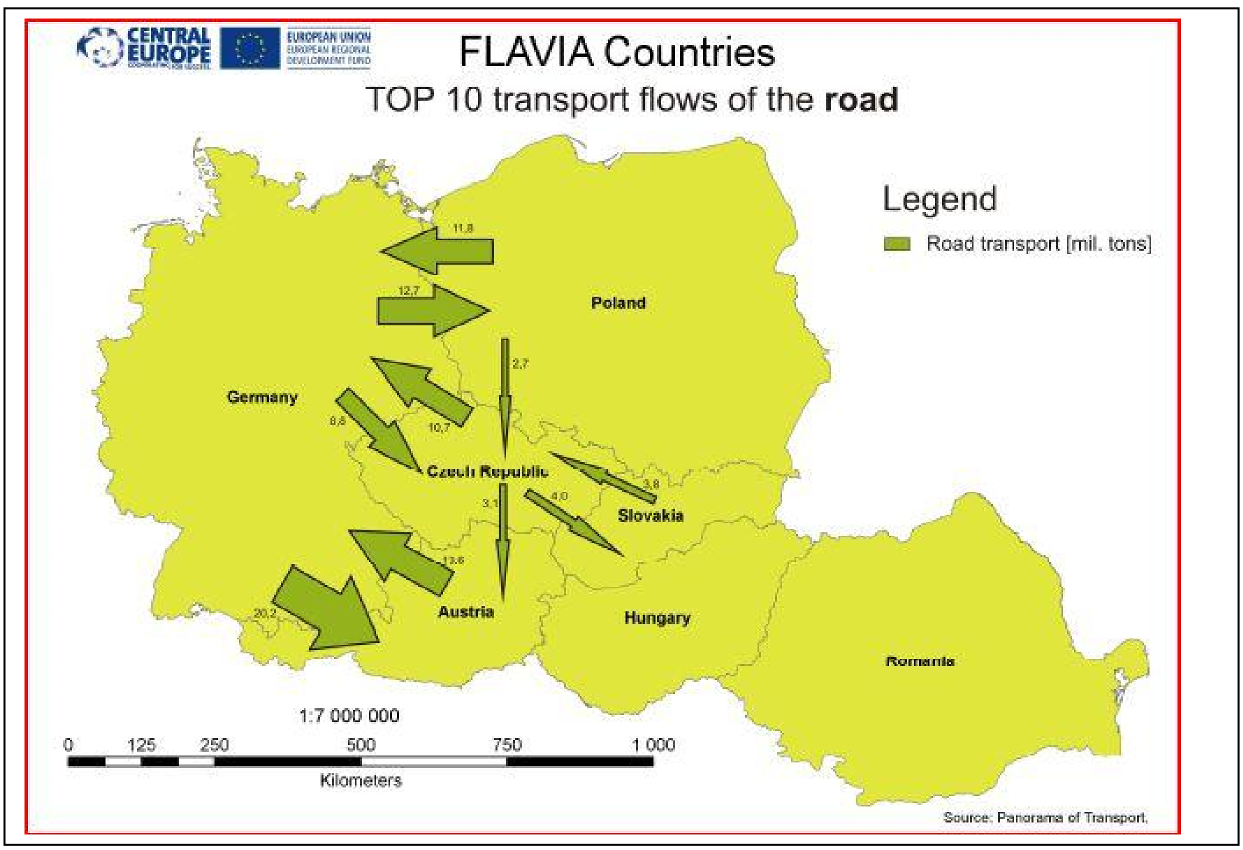


Figure 8: Top 10 Road Transport Flows

Source: EUROSTAT - **2009, representing year 2006**

One criterion is the total cargo flows by road and rail to and from a country or region. In general, modal choice favors rail for movements of greater than 500 km, which identifies cargo flows moving to/from one or more adjacent countries, of which one is a relatively large country. Those flows point to Germany and **Figure 8** and **Figure 9** illustrate this. The fact that heavy transport flows exist indicates both the density of economic activity and that the types of industries that can use railways are concentrated in the country and/or region. And that means there are also economies of scale to support rail.

Road transport flows are important, because it is from that mode that rail will likely draw its increases. High motor carrier cargo flows mean higher potential for cargo to shift to rail.

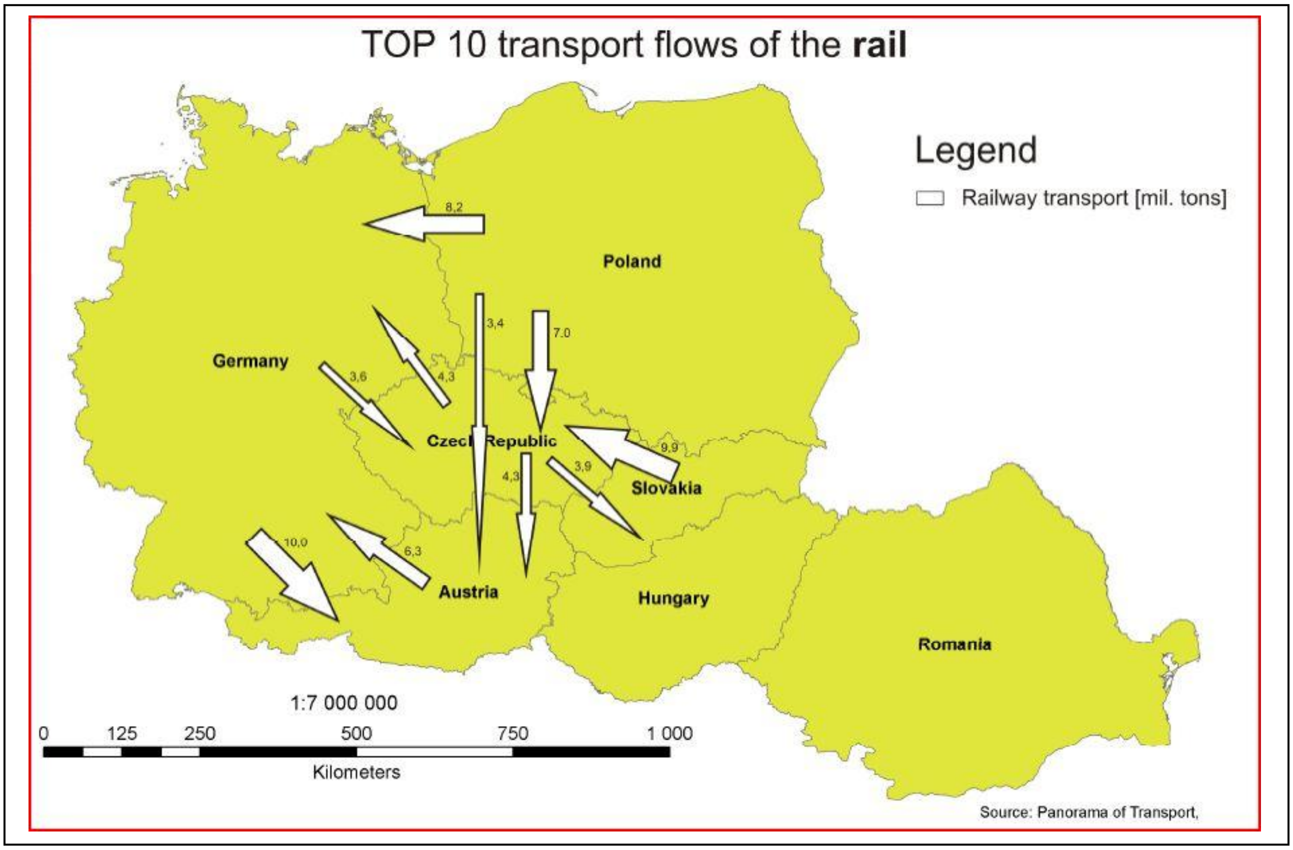


Figure 9: Top 10 Rail Transport Flows

Source: EuroStat - 2009, representing year 2006

The existence of high rail transport flows is important because the heavy volumes mean that corridors have already been developed and are in place to accommodate the traffic.

Another criterion is the distribution of intermodal terminals. Intermodal (CT) traffic has the highest probability of being shifted from road to rail, but the terminals must be available for this to occur. The map in **Figure 10** shows the terminals within Germany and countries to the East and Southeast, along with their catchment areas, also linked by railway corridors.

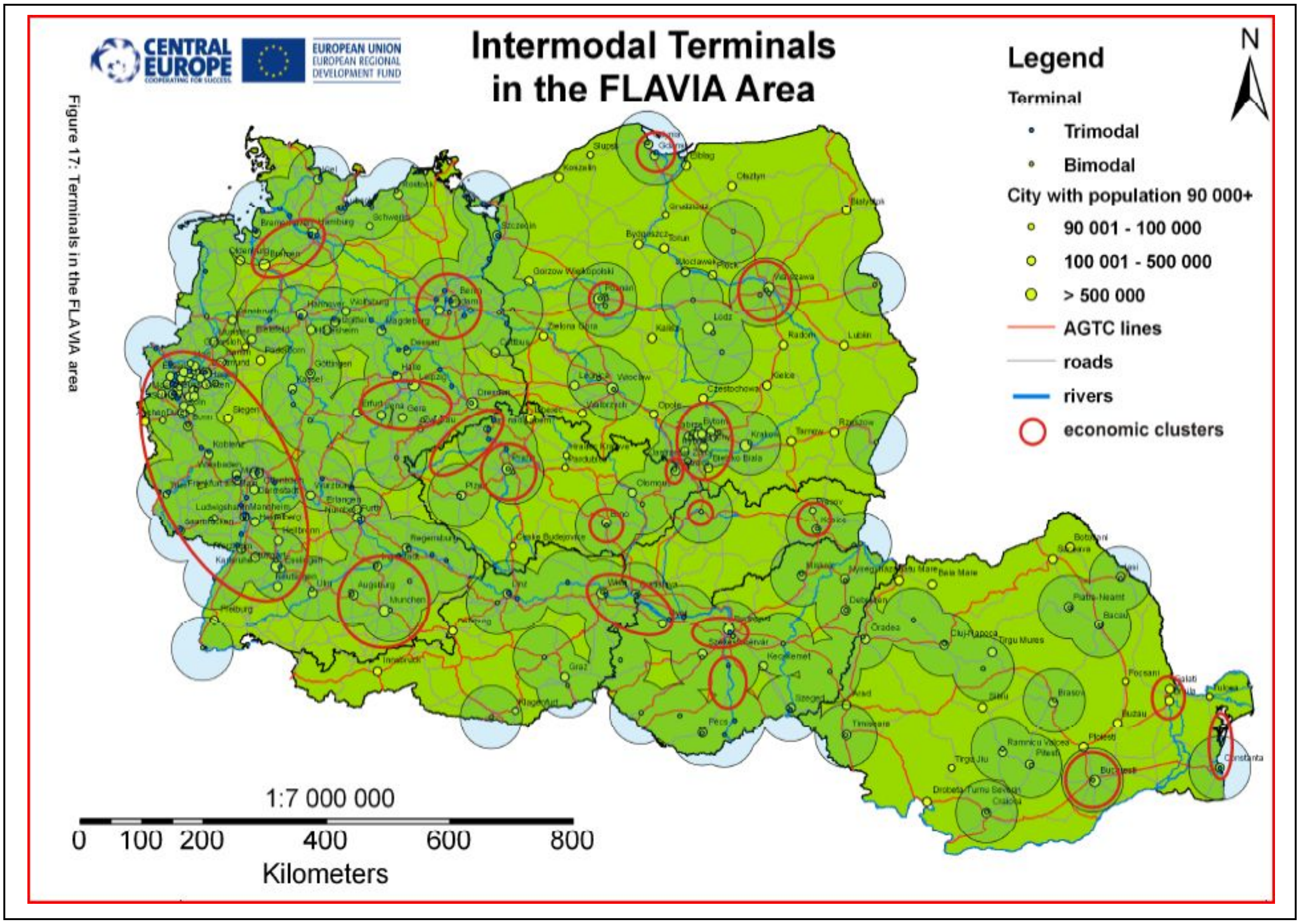


Figure 10: Intermodal Terminals & Catchment Areas

SOURCE: FLAVIA REPORT

Once we have identified a country and/or region(s), determining the modal shift after an integrated company becomes an actor in the area, operating on a specific corridor, it will have to take many factors into account. An integrated company will operate out of a terminal, and it follows that the sample corridor selected will have large volume terminals and catchment territories, such as a large metropolitan area. Examples of large volume terminals that also have large catchment areas would be seaports like Rotterdam, Antwerp, Hamburg or Bremerhaven.

It is the areas near and along the established flow of traffic that are interesting. A helpful tool to use for criteria to confirm a corridor's traffic volume would be Eurostat's ***"Nomenclature of Territorial Units for Statistics"*** **(NUTS)** data, where source and target regions would be selected.

The following criteria would also apply:

- The cargo originates or terminates in the terminal (port) area, which assumes non-local traffic along a selected corridor (a sizeable catchment area)

- Trips greater than 500 km from the originating terminal and with a preference for cross-border traffic

4.8 Desirable Corridor Factors

The broad framework for the process of selecting corridors, based on the criteria for desirable attributes, are in the following subsections. In all cases, the fixed and variable cost factors associated with the various corridor attributes relate back to the objective of the research question, which is to "…*develop a profitable business model in the newly liberated commercial market and regulatory environment in the EU… …with or without integrating complementary business elements ("bolt-on"), as either separate or related enterprises."*

4.8.1 Characteristics of the Network Route

The core corridor characteristics of a route in the network would drive inputs into the model in the form of estimated cargo traffic volume. Those characteristics are defined as based on three pillars:

- Build missing cross-border connections, strengthen current connections and remove bottlenecks
- Integrate different transport modes (multimodality)
- Promote technical interoperability [50]

An RU handling that cargo volume would, in turn, generate variable costs, which are inputs for the costing model. The characteristics can be classified as broad or unique to a specific route. When route costs are uniquely specific, as inputs into the costing model, they will be so noted.

4.8.2 Connectivity

Connectivity is defined here as selecting a route that uses stations situated within, connecting either within its own, or within or over multiple corridors for transit. This coincides with the

[50] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), Page 38.

three pillar corridor characteristics listed in 4.8.1. Said in a different way, it would be selecting a route that includes multi-corridor stations. This is a broad classification and the model input would be classified as a variable cost under infrastructure costs (IC), relating to capacity slots or paths.

4.8.3 Traffic Generators

Economic activities drive freight traffic generation. Transport demand is derived and "necessary because goods are produced and consumed in different locations".[51] The route would be within regions where there are traffic generators, hence building a base of traffic volume. Local regional economies with production, warehousing and distribution centers and/or local regional economies also oriented towards consumption are natural links to generate traffic. In other words, operating within and between economic clusters (broadly defined as complementary business subsectors concentrated in and between regions). That model input from those routings would be classified under variable costs for infrastructure, energy, personnel time and terminals costs, as well, if appropriate.

4.8.4 Population Concentration

State and regional population concentrations, versus dispersed population distributions, are necessary for achieving scale. That model input from those O/D pairs and hence, routings, would be classified under variable costs for infrastructure, energy, personnel time and terminals costs, as appropriate.

4.8.5 Route distance

An influential variable for shippers' modal choice of rail is the distance of the shipment. "The average distance covered per ton is the highest in rail traffic".[52] The route should have distances long enough between origins and destinations to capitalize on rail's natural efficiencies. This also leads to the prospect of through (bridge) traffic volume (between regions and countries). If the trains are operating as a "liner" service (making stops along the route to terminals and dropping off or picking up wagons) vs. the fixed consists of intermodal wagon trains modeled in this research, then those variable costs would apply, as well as the fixed direct costs of the rolling stock needed for the traffic.

4.8.6 Traffic Balance

A route should offer the probability of balanced traffic volumes in both directions. In either case, the variable (operating) costs would still apply, whether the wagons were loaded or empty, as the train must still return to the starting or origin point.

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[51] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), P. 294, Section 2.2.2.

[52] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), P. 304, No. 2.

4.8.7 Summary of Desirable Network Route Characteristics

The above characteristics can be summarized as the process of identifying main economic centers or "economic gravity points" that generate transport demand by establishing candidate origin and destination points. Route characteristics fall under variable costs and provide inputs to infrastructure (IC), relating to capacity slots or paths, driven by distances between O/D pairs, operating personnel required for the time needed to traverse the path (LCOH), energy costs (E), related to the weight and length of train permitted and possibly terminal costs, depending on whether the transport decision maker is responsible for those costs or not. If the RU is responsible, then that category falls under terminal costs (TC).

4.9 Traffic Types

The traffic customer and commodity types identified over a network route should offer reasonable prospects of use of rail. Although the focus of this research is shifting truck traffic to rail, the presence of volumes of low value to weight ratio, such as "solid fuels, ores, metal industry output" signifies that there is substantial economic and industrial activity in the region.[53] This factor links to the variable cost labeled equipment costs, under which the subcategories of wagon and locomotive costs are classified ($L_{R} + W_{R}$), along with their relatively minor "running maintenance" costs (WSM and LRSM). Any container rental or related costs will not be included, because the freight forwarders and/or trucking companies are providing the cargo loading units.

4.9.1 Captive Shippers

This comprises the customers and shippers who prefer to and/or must always ship by rail (low time sensitivity, lower value and/or bulk commodities), given the superior economics of rail for those commodities. These types of cargo and customers are not targeted for this research, but a factor for more traditional rail traffic.

4.9.2. Customers in Stable Sectors

In this context, example cyclical products are defined as discretionary goods, such as consumer electronics, garments, autos and new auto parts, recreational products and the like. Secular products are more inputs to production, such as bulk commodities, ores, petroleum products, chemicals, stone and like goods that are needed on an ongoing basis to provide basic services and goods. The customers and the nature of their cargo affect the model through the variable costs of the types of freight wagons required to handle their traffic.

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[53] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), P. 304, No. 1.

4.9.3. Traffic with Higher Probabilities of Shift to Rail

These types of commodities are often transported in truck trailers and containers. This type of traffic is more time sensitive and generally is of higher value. Therefore, the tariffs could be higher, along with transport customers' expectations of reliability and consistency being higher, as well. This type of traffic is generally preferred, especially truck trailers, because the possibilities of achieving a loaded return train and equipment cycles are more favorable. It is this category of traffic that is the focus of this research and it affects the input into the model through the variable cost of the types of wagons needed for this traffic. Operationally, this type of operation is point-to-point vs a liner or conventional, traditional rail cargo train, which make stops along the route for wagon pick up and drop-offs at marshalling yards and terminals. Point-to-point operations generally affect variable personnel, energy and equipment costs positively, through reductions in time, energy by less circuitous routing and acceleration/deceleration events and better equipment utilization, respectively.

4.10 Regulatory Characteristics of the Corridor

4.10.1 General Operations

The operations over the corridor route, if operating and transiting more than one country, at least one of which not in the European Union, must have operations that are without border delays. This means that crew changes, maintenance work will take place at border crossings and crew change points. In terms of safety regulations across borders, safety management organizations would subscribe to the same common rules across all borders. To the degree technically possible, this will also mean interoperability of locomotives. This affects the variable costs of equipment (cycles possible), crew costs and fixed administrative burden.

4.10.2 Customs Procedures

Customs procedures related delays need to be eliminated over the route(s) between EU and non-EU regions. This affects the variable costs of personnel and equipment costs, as the cycle time of the equipment would be adversely affected with border administrative delays.

4.10.3 Interoperability of Locomotives

To the degree possible, interoperability of locomotives – also requiring the abolition of meaningless homologation processes to prevent locomotives from other countries and/or manufacturers from being accepted into service. This would affect variable costs of equipment, since if there were more interoperability, less of different types of locomotives would be required.

4.10.4 Cross Border Safety Management

Safety management organizations would subscribe to the same common rules across all borders. This affects the variable costs of personnel, as common crews for across the border operations are more efficient than a different crew every time the train crosses a border.

4.10.5 Administrative Processes

Simplified business and commercial processes especially regarding customs to/from non-EU countries. This factor relates to personnel costs (less time), equipment utilization (equipment – EC) costs.

4.11 Physical Attributes of the Corridor Route

4.11.1 Route Characteristics

Characteristics of the line consider certain restrictions governing the management of operations, train handling methods, types of locomotives used, train length, axle weight and overall trailing tonnage of the train, as follows. Generally, this affects the variable costs of infrastructure (direct or circuitous routing), personnel (time required to travel a route), number of wagons and their type (equipment costs and running maintenance), and energy costs.

4.11.2 Line Profile

Line profile will consider the factors of curvature, gradient, weight (both trailing tons and on a per-axle basis), and dimensional restrictions (high and wide loads). This affects the variable costs of energy, infrastructure (different routings, more circuitous or direct), cost of the types of locomotives required and personnel costs and wagons needed for the traffic. This also affects the maximum size of the train, affecting both variable costs and revenue.

4.11.3 Line Operational Characteristics

Line operating characteristics, such as length of sidings, single or double-track plus main line, dispatching priority of freight vs. passenger, ability to get paths, primary vs. secondary corridor involve the same variable costs as above.

4.11.4 Line Condition

Condition of the line (line/track speed, weight restrictions and dimensional restrictions). The same variable costs as above.

4.11.5 Unique Natural Conditions

The frequency and intensity of unique or adverse weather conditions, such as flooding, avalanches, frost heaves, etc. need to be considered. The variable costs that will be most affected will be infrastructure (rerouting), personnel (increase or decrease in time required) and energy costs.

4.11.6 Line Traction

Type of traction – electric or diesel affect variable costs, related to energy and trailing tonnage and axle weight limits, given the line profile (curvature, gradient and maximum tonnage allowed due to bridge weight restrictions, clearances and potential passenger schedule interference, due to train performance characteristics). In general, energy costs will be higher using diesel vs electric locomotives, but some routes are not electrified, leaving no operational choice. Energy costs are thus affected. On a positive note, it is easier to find a diesel locomotive homologated for operation in multiple countries, because the traction power is developed by the engine in the locomotive (either through electric or hydraulic transmission), as opposed to drawing power of different voltages, frequency (if AC power) or the correct voltage if it is a DC powered locomotive.

4.11.7 Line Connectivity

Connectivity to terminals and hubs and supporting infrastructure. This factor will affect the variable costs of infrastructure (routing and allowed use of certain routes), personnel costs (due to operational time required), and the use of different types of traction, (diesel vs electric). Also affected are variable costs of the number and type of wagons in the train. In general, the length and tonnage of the train will be governed by the most restrictive characteristic of the railway route. The length of the origin and/or destination terminal tracks could also govern, unless there are pickups and drop-offs enroute, as it would be with a liner or traditional rail cargo freight train. Then, the operating scenario and variable costs associated with that type of operation would be modeled.

4.11.8 Line Port Connectivity

Connectivity to sea and river ports and supporting infrastructure. As mentioned in the previous item above, the variable costs will be affected by the routing to and from the infrastructure within the port areas. Port rail infrastructure that has limited track length affects variable costs, by the maximum number of wagons that can be handled on a track, unless individual train segments or wagons are combined by shunting. Shunting adds to variable terminal costs (TC), by the variables train shunting and handling (TSH) and wagon shunting and handling (WSH). In the scenarios modeled for this research, there is no terminal handling involved, other than loading and unloading, because these are fixed intermodal trains.

4.11.9 Line Terminal Electrification

Are the tracks of ports, terminals or hubs electrified? This factor affects the variable terminal costs (TC), as well as a possible combination of wagon shunting and handling (WSH) and/or train shunting and handling (TSH). Terminal configurations can differ, with some requiring only that the train be shunted to an electrified track that allows the locomotive(s) to couple onto the train. Other operations might use a non-electric shunting locomotive to move the electric locomotive onto the train and then move the entire consist to an electrified departure track.

4.12 Corridor Universe – EU Application

While the overall intention of this research is the development of a cost simulation model and supporting methodology as a tool to apply to railways universally, the data needed for this dissertation is more available within the EU. Therefore, for the purposes of this research, these research tools will be applied to EU sample corridors. With respect to identifying corridors to examine in an EU application, another part of the methodology would be to examine traffic flow between regional zones between selected corridors of the TEN-T network to a minimum of the NUTS 2 level, as the regional zones would be centers of economic activity.

Actual traffic composition and volume data associated with individual corridors, specific territories and/or RUs will likely prove difficult to get, due to its proprietary nature. However, as mentioned earlier in this chapter, workarounds have been found. Similarly, actual operational costs could also be problematic from RUs, although there are some general costs that can be applied to the model with reasonable confidence of accuracy.

Lastly, as a reality check, one would implement the “Delphi” method and speak with ports, rail and terminal operators, freight forwarders and integrated companies to get insights on operational practices, as well as empirical data, if possible and as did occur. While much of their internally generated data is proprietary, some discussion with them would be (and was), helpful to gain perspective and gather random mosaic pieces, however incremental that might be, to help complete the picture.

The next two figures show maps of the TEN-T rail freight corridors in Europe, both cartographically and graphically.

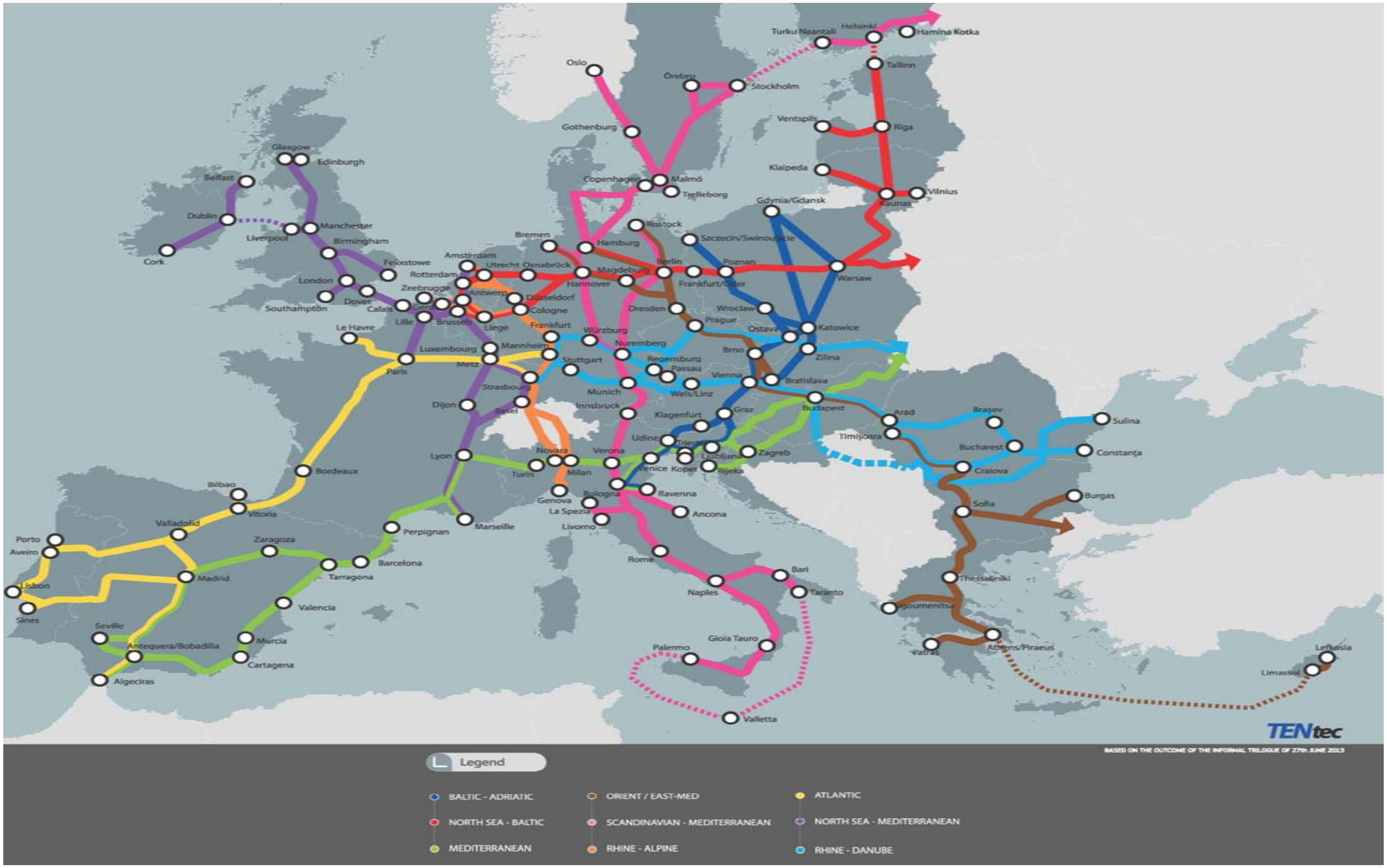

Figure 11:TEN-T corridors of Europe

Source: European Commission TEN-T Program

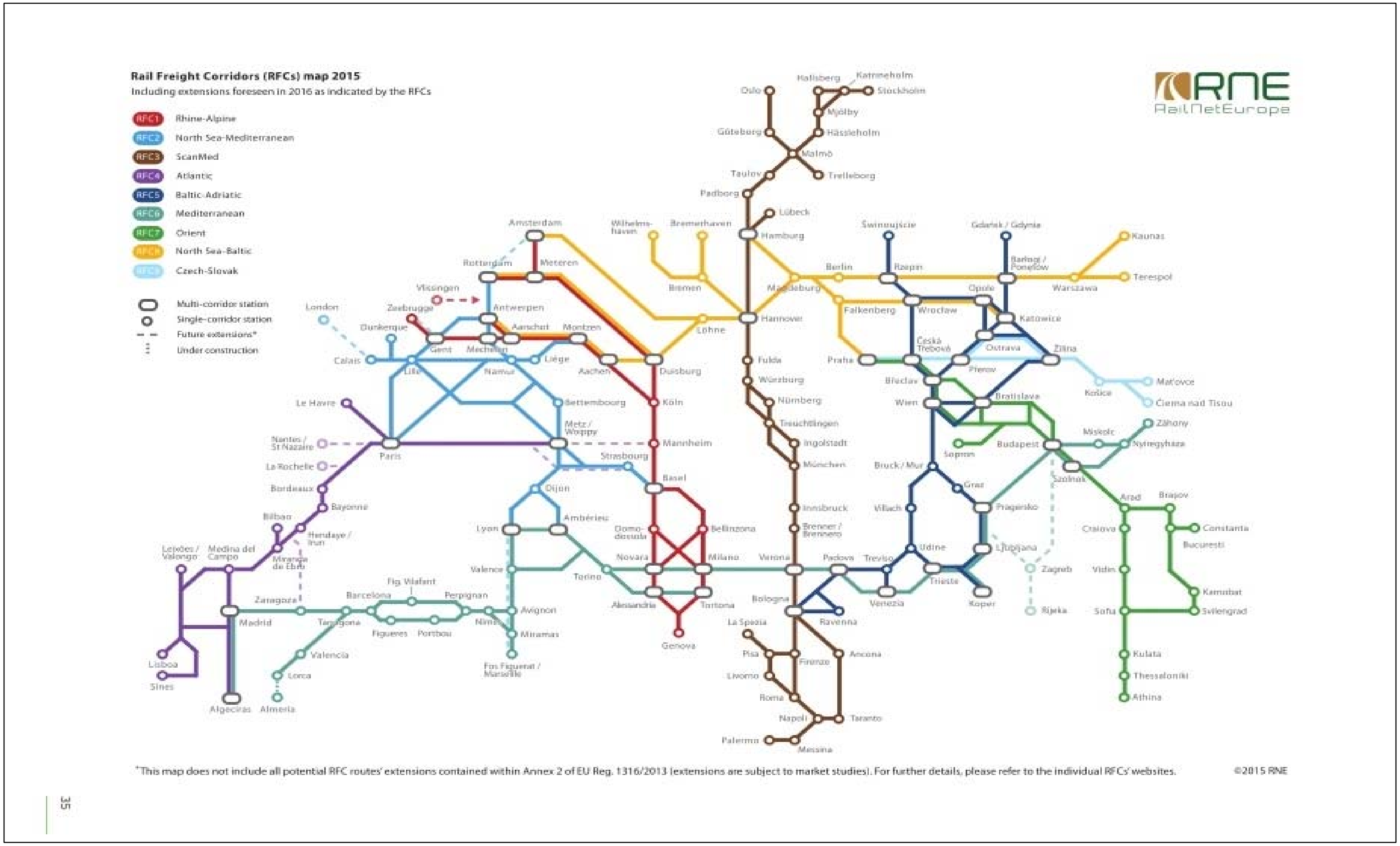

Figure 12: Rail Freight Corridors of Europe

Source: RFC Website

4.13 Cost Model Details

A costing model with the characteristics of an engineering approach, combined with activity-based modeling will be used, with a detailed compilation of costs considered. To reiterate, a motivation for using this approach is the paucity of recent and sufficiently disaggregated data and the need to work backwards from a cost approach to a highly granular compilation of costs, from a "bottom-up" method, facilitating profitable pricing and hence, maximizing profitability. The costing model is designed and intended to be a platform for not only evaluating the eight selected cases in section **5.3 Choices of O/D Pairs**, but also as a template for further research, adding different routes, types of rolling stock and the addition of the trucking mode to evaluate the financial performance of a multimodal and/or multi-commodity equipment and route choices.

Engineering and Activity-Based Approach

Some structure is necessary for this model. The first is to establish a methodological framework to determine costs and revenues for selected O/D pairs. The combined engineering approach described above involves a detailed compilation of cost elements and will be detailed further in this chapter.

4.13.1 Differing Costs for Route Segment Path Costs.

The route segments along the corridor will have different costs from each other and will vary by the O/D combinations. It is possible that one RU and its affiliates may handle the train along the entire route, but an equally conceivable scenario that multiple RUs will operate the train along their respective segments along the corridor. To review, originally, the intention was to average all costs along the corridor route. Regardless of if there are independent RUs or one larger and integrated RU that conducts train operations, under some conditions, the costs were to be blended to arrive at an average total cost for a specific cost element of operation, to avoid ferreting out each cost element in exhaustive detail. This proved not to be as useful to answer the research question.

In later iterations of the cost analysis process, tools were discovered to determine path costs more precisely for each country's route along the corridor selected, depending on the O/D pair. Those tools are explained in more detail in **Chapter Five – Empirical Application of the Cost Model** section.

4.13.1.1 Differing Costs for Sub-Network Route Segment Path Costs

Another variable is the selection of sub-network routes *within each country*, which are not always the most direct paths between points. Often, the paths are governed by the classes of track, with respect to tons per axle, train length limits and line characteristics, such as length of sidings, total train tonnages (which can affect passenger train operations, through freight train performance characteristics), or even whether a line segment is electrified or not.

4.13.2 Differing Costs for Route Segment Energy Costs.

Other examples of differing costs over route segment are energy costs. Each network operator publishes a base energy cost per kWh, but the actual cost can vary by day (holiday or normal day), time (peak demand during the day vs. off-peak night rates), region, how energy is generated (renewable, nuclear or fossil fuels) and other factors. In this case, energy costs must be averaged per kWh for the country of the network.

4.13.3 Ancillary Charges from Network Authorities.

Network reservations also incur charges, which are nominal, if made far enough in advance, but costly if the path is needed on a short-term basis.

4.13.4 Train Handling at Border Crossings.

How trains are handled at the border and the costs for changing locomotives and the time spent doing so are also chargeable events. As an example, the cost for changing a locomotive in either direction between Germany and Poland is approximately €300, at the time of this writing. (Source: Rail Polska Z.o.o.). Between Germany and Netherlands, in each direction, the cost is €500.

4.13.5 Train Length and Weight.

The length and weight of the train over a route segment is governed by the most restrictive operational constraints along the network path(s) from origin to destination, which in turn, will determine the maximum number of wagons in the train. A realistic mix of loading units determines the types of wagons and their likely costs and revenue per loading unit. The combination of all loading units and wagons will also help determine a conservative assessment of revenue attained.

4.13.6 Pre and Post Handling Costs.

Costs are applied to each of the beginning and ending corridor segments of the O/D pairs selected, to compile costs of “Pre and Post Handling” (PPH), assuming combined transport (CT) and arriving at a cost basis per loading unit. In general, the freight forwarder or trucking firm embeds this in their cost of transport to the customer.

4.13.7 Locomotive and Wagon Costs.

Due to the high initial capital costs of rolling stock, the cost model assumes that the locomotives and wagons will be leased and not owned outright by the RU’s.

Costing data will draw from a compilation of the individual cost elements that comprise rail operations on as granular a level as possible. This will entail examining potential operations in a range of EU countries, consistent with the candidate corridors being contemplated.

4.14 Simulation and Analysis Processes

With the empirical data compiled into the appropriate (useful) level of disaggregation, simulation can now take place in iterations.

4.14.1 Realistic Operational Scenarios

There are several components of the model that must act in concert for the model to accurately represent realistic operational possibilities, given the O/D combinations and corridor segments required for service delivery. To deliver the service product required by customers, paths in network capacity over the selected corridor must be identified that correspond to customer schedule expectations. Obtaining these slots is critical to consistent service delivery, defined as an indispensable quality characteristic by the customers.

4.14.2 Optimal Operational Scenario Choices

The process involves analyzing the data available and deriving sample operational scenarios to compare cost structure, with the goal of determining maximum profit. However, much of this analysis relies on sampling derived one-way trips over paths linking O/D pairs. There are at least two assumptions in these scenarios:

1) The round trip will assume the possibility of an unloaded (empty), one-way segment, with all fixed and variable costs, through the variable of loading units per one-way trip segment.

2) The goal of converting the unloaded (empty), one-way segment to at least a partially loaded segment.

That data, though with limited availability, analyzed, can at least give an indicative sense of the cargo composition and tonnage volume between O/D pairs to link traffic-generating production and consumption regions in either direction of the traffic flow. The limited data available does allow that in a coarse way and for that reason, the Ports of Rotterdam and Antwerp are paired with regional economic clusters in Poland. Poland is selected, because there is traffic density over a distance long enough to capitalize on the natural advantages of rail serving non-port (inland) regions and for which the data indicates a flow of return traffic to the port regions.

Operating (variable) costs include infrastructure and energy charges, operating crews and fixed costs include lease of equipment (locomotives and railcars), maintenance, insurance and sales, general and administrative ("SG&A"). If the type of traffic selected includes observed and historical volumes of potentially containerized commodities in either direction, then the same wagon equipment can be used for partially, if not completely paid-for one-way trip segments that would otherwise be empty and non-revenue equipment positioning trips. This means train compositions exclusively using pocket wagons for truck trailers, as there is far more traffic volume moving by truck between the two regions in both directions.

4.14.3 Realistic Operational Frequencies

As criteria for qualifying traffic levels, we assume here, based on the empirical data developed, that the traffic volume will be sufficient to justify at least two trains a week in each direction over the corridor segments serving the O/D pair. This frequency is the minimum to attract freight forwarder, 3PL and shipper interest, based on Delphi method sourced data. Like the original model used in the REORIENT project, factors affecting performance, such as actual transit times along corridor segments and delays at terminal nodes and corridor intersections, as well as consistency must be considered.

Another added advantage is that even for a trip with only partial revenue, the operation establishes a service frequency that freight forwarders and customers can rely upon and is attractive, which helps the RU to build traffic. The certainty of consistent scheduling then allows freight forwarders and other intermediaries to apply marketing efforts, as well as direct shippers a schedule they can rely upon.

4.14.4 Consistency with Optimal Business Service Models

The processes listed above are consistent with the business models **1, 4 and 5**, discussed in greater detail in **Chapter 3** and summarized below.

Of those service models, three emerge as a starting point for potentially the most viable and they are:

> ***Model 1:*** *RU integrated with a 3PL*
> ***Model 4:*** *3PL (logistics company) making agreements with customers and subcontracting with an RU / traction provider*
> ***Model 5:*** *RU (operator) and all customers (shippers) make direct agreements and/or originate/terminate traffic to/from connecting RU(s)*

Models 1 and 4 have been selected, because they are judged to have better possibilities of developing scale, particularly in newly liberalized service environments. In the case of Europe, the reasons for this are that the distances between origin and destination are often insufficient to capitalize on the efficiency of rail, generally realized over distances greater than 500 km. The two model variations offer the prospect of shipment aggregation to partially offset the shorter distances through volume. Similarly, the RU must partner with a 3PL or freight forwarders whose commercial interests are aligned with the RU. In the European environment, the customers are often too small to generate large shipment quantities and the 3PLs and freight forwarders are in a better position to aggregate traffic to achieve the scale necessary for rail transport. The key assumption for models 1 and 4 to work is that their respective economic interests are commonly aligned, in the form of direct economic benefit and/or being linked together in the same holding enterprise.

Model 5 is also selected, because the RU has a direct connection with the customer, bypassing any unintended (or intended), communication filters or obstructions from another party in the customer relationship. Small details can often be the difference between success and failure in capturing the customer's business by obtaining favorable rates and service levels from connecting RUs*.*

The core concept is to combine efforts with traffic generating enterprises to give the highest possibility of filling out a train from multiple sources. It also allows cooperation, even between competing enterprises (both RUs and trucks), in that they all participate in building a train to the capacity needed for profitable operation, thus adding a train frequency and overall attraction of rail service over that route.

4.14.5 Process Indicating Traffic Scenario Choice Changes

Given the processes outlined in **4.14.2** to **4.14.4**, the objective of data analysis is to determine the densest routes by commodities of the type that would travel in both truck and/or containers between OD pairs by tons by rail and truck.

However, this would mean that the selection of equipment (wagons) for trains would shift from the previous commodity mix hauling:

- ***From*** a combination of bulk, low value commodities (ores, grains, coal, timber, stone, coal ash, etc.) and flat wagons for containers
- ***To*** that of a combination of pocket wagons for trucks and truck trailers, as well as flat wagons for containers.

For this analysis, a combined transport (CT or intermodal) train would be the train modeled, vs. a mixed consist of wagons.

That does not mean that traffic with bulk commodities would be turned down, if the opportunities presented themselves and there was sufficient train length to accommodate those wagons. But, for the purpose of analysis, this appeared to be the best scenario for reliably consistent traffic over a longer trip distance. [54]

4.15 Application of the Process Procedure Overview

4.15.1 Summary of Procedure

To succinctly describe the processes to develop a simulation and analyze disaggregated data developed, the following is a summary of the methodological approach applied to estimate potential modal shift to rail in the corridor selected.

4.15.2 Determine Candidate Corridors

From the universe of choices derived from the disaggregate data collected, this part of the selection process would identify the volume of potential traffic of target commodities, moving in the candidate corridor(s), for commodities now moving by truck in trailers or containers.

4.15.3 Conversion of Tonnages to TEU and Loading Units

From the tonnages derived from the data, to develop and apply a conversion model from tonnage to TEU to equivalent loading units. The number of loading units would determine the type and number of wagons needed, necessary for the costing model calculation of equipment lease, maintenance, path and energy costs. This conversion model is detailed in **Appendix B.8**.

4.15.4 Determine Route Costing Elements

Once candidate routes have been selected, then apply costing data elements to the route, beginning with, for container or trailer traffic, estimated pre and post haulage (PPH) costs (by road, if applicable), originating terminal, line haul, terminating hub or terminal costs, along with an overhead (administrative) factor. The approximate costing of rail movement of trailer or container traffic on the selected route would thus be derived.

The intent of establishing this process of analysis would be to assess the costs of prospective operations over a route, given a sample matrix of O/D pairs. While measuring every O/D pair along the route with its commodity combinations would be beyond the scope of this research, the procedural framework would be thus established to execute such an analysis of the data for application to the detailed procedural steps more fully described in Chapter Five.

[54] Per discussions with Delphi source Baltic Rail Express and Rail Polska z.o.o.

4.16 Summary and Conclusions

With the methodological structure established, the empirical data available, the core elements would now be in place to conduct analyses on the extracted data to move towards answering the research question.

Also, with the question settled of which RU typology and service model from a range of options would be the best, the next step was to examine the range of models that are traditionally applied to analyze transportation scenarios, in the context of the research question, with the intention of not only profitability, but also profit maximization.

What became clearer after stepping back to get an overview perspective was that almost all of the models surveyed yielded their result through either inferred data or the probability that a range of optimum financial results would be indicated. Further, the data available for these models were too aggregate to be of value to answer the research questions.

Unsurprisingly, aggregate data yields aggregate answers. What became manifestly obvious in the depth of the research was that empirical e.g., actual, observable and disaggregated data was required, which was not available from traditional sources, such as Eurostat and port statistics offices.

The data sourcing options that remained were either proprietary data, generally unobtainable, without great cost or undertaking the task of extracting data from multiple tables that were originally sourced from Eurostat and currently also unavailable. Considerable research yielded the discovery of portions of data from multiple research projects that was sufficiently disaggregated to be useful to this PhD and from which that data was analyzed and combined into tables that specifically included data elements needed to conduct useful analysis.

That shifted the type of model from a relatively straightforward, but simpler cost model with an engineering approach to a model that would consider costing the elements comprising the actual activity of conducting transportation service delivery. The key concept that persistently emerged in the ongoing research was "activity" and so the model to be implemented was then refined into a hybrid cost calculation model with an activity-based approach. By doing so, the indispensable factor of revenue was also integrated.

The process of data extraction was rather lengthy and driven by the detailed needs of the hybrid model. This required multiple iterations of analysis to determine the precise elements of data needed for the model. Some of those data elements were results calculated from other data elements (fields) from different tables. Most importantly, tables were grouped by complementary data into separate data tables to be linked together with common data elements, such as origin and destination codes, NST2 (commodity) codes and filtered by tonnage values and O/D pair codes, using Microsoft Access. From this core data, queries using

SQL language were used to generate larger, combined tables that would be filtered to derive the underlying tables needed for analysis.

To aid in the selection and data synthesis process, a detailed decision tree was developed to maintain an overview perspective of the entire process, integrating criteria established for route selection. The route characteristics were compared against desirable attributes of the route(s). This decision tree can be viewed in **Section 4.6.9** in **Figure 7: Overall Modeling Structure.**

Also overlain were general overviews of the density of traffic flows between regions, which also served as a starting guide to pre-analyze and confirm tonnage flows between O/D pairs, as well as to get a perspective of the types of terminals and their catchment areas. The figures illustrating those overviews can be viewed in **Section 4.7 – Flow Sources and Geographic Selection Criteria – Europe** in **Figure 8: Top 10 Road Transport Flows, Figure 9: Top 10 Rail Transport Flows** and **Figure 10: Intermodal Terminals & Catchment Areas**.

With all the selected and filtered data elements now collected into combined tables using the process described above, the core data needed for the model was complete. The next step required was designing an Excel spreadsheet application to apply, using the costing elements as reference data, as pertaining to the defined candidate routes. The application was now in play to use the now filtered data generated from the large body of base disaggregate data tables.

Costing elements had to then be established over the broad categories of fixed indirect and direct costs and variable costs and based on fundamental accounting principles. Consistent with the nature of the activity-based model, it was necessary to define costs on a granular level to ensure that true costs of each activity were captured. Delphi sources, in combination with business models submitted to this author for investment evaluation, further clarified through verbal discussions by their makers, as to the bases of costs helped establish veracity. With the individual cost elements now established and in place, they could then be included in the formulas for later analyses.

Most critically, the cost basis for each activity element could then be integrated into the spreadsheet application, the calculations of which could be applied formulaically within cells and/or through reference tables as data for cost bases. The advantage of having separate sections (worksheet tabs) with reference tables is that the underlying values can easily be changed in one location to apply to multiple scenarios.

With criteria established, as to the characteristics of the routes, reference tables with known base values needed for cost calculations and formulas allowing aggregate processing of the entire spectrum of data, it was then possible to enter values into key cells to observe financial results.

Calibration of the model would be straightforward, as the results of the model would have to pass the reasonability test with Delphi sources, as well as with the judgement and experience of the author, all of whom will be able to readily detect anomalies. [55]

Chapter 5 describes further steps to refine the data into more useable form, conduct comparisons between selected O/D pairs for traffic volume and financial viability and draw conclusions, as to what routes combinations are optimal and/or identify routes to avoid.

[55] The author's rail experience is sourced from the collective experience of evaluating the prospects of shortline railroads in North America for public jurisdictions, such as economic development agencies, state departments of transportation, private investors and in the case of Europe, evaluating RU prospects and cross-checking with Delphi sources already operating RUs in Poland (Rail Polska Z.o.o), Estonia (Baltic Rail Express), Germany (Nordliner GmbH), Sweden (Tågåkeriet i Bergslagen AB), as well as collaboration and evaluating the prospects of establishing and serving the Port of Hirtshals in Denmark, as an prospective investment candidate.

Chapter 5 – Empirical Application of the Cost Model

5.1 Introduction

The overall purpose of this chapter is to gather input for the cost model in the form of examining the raw data to select origin destination pairs, which are filtered by the route characteristics listed below in **Section 5.2.6 – Summary of the Rationale for Selected Matrices of O/D Pairs.**

The O/D pairs selected through the filtered criteria, will be modeled by applying cost elements on a reasonably granular level to aggregated activities simulating operations to conduct railway operations over that route. The costs, both fixed and variable, will be totaled for each O/D pair operating scenario. Realistic revenues will be estimated for each O/D pair scenario and combined with total costs, will be analyzed, with the objective of profit maximization. Each scenario will be compared for interpretation and discussion of further strategies to maximize profit.

The type of traffic volume targeted is classified as "intermodal", is defined as *"Movement of goods (in one and the same loading unit or vehicle), by successive modes of transport without handling of the goods themselves when changing modes"* by the Organisation for Economic Co-operation and Development (OECD).

In terms of data reliability, the original source of the traffic flow data was from EuroStat and as mentioned in **Section 4.3.3.1**, was on a NUTS3 level of disaggregation and the commodity classifications (NST/R), was based on the reference year 2007 with 24 commodity groups, both bodies of data of which are longer available at the level of disaggregation needed for more precision.

As regards operational costs, the source of the data was largely through both the network statements of the respective countries traversed, as well as DB Netz's Trassenfinder.de, which simulates costs given the parameters of train weight, number of wagons, origin, destination and type of train. Given those parameters, DB Netz calculates network access charges, estimated energy usage and estimated transit time. To the degree possible, operational scenarios were cross-checked with Delphi sources for reality consultation.

5.2 Traffic Flows

A fundamental step in the methodological framework is to identify candidate corridors for a more focused analysis of selected O/D pairs. The analysis will determine the potential volume of target commodities, especially those moved by trucks in either containers, trucks or truck trailers.

This will require applying a formula to convert tonnage to TEU and into an equivalent number of loading units, whether containers or trailers. The number of loading units will determine the approximate number and type of wagons needed, which are necessary inputs for the costing model calculation of equipment lease, maintenance and path costs. Trucks, trailers and other loading units can vary greatly, so for initial identification of candidate corridors, this analysis will focus only on cranable, uniformly sized loading units, such as the 20 ft. and 40 ft. containers and standard 40 ft. truck trailers, for which the railway wagons are designed to carry.

5.2.1 Conversion of Tonnage to Loading Units

To convert freight category tonnage volume data into something usable, one would need to see the relationship between the category of freight shipped and the loading unit used, such as a 20, 30, 40 or 45 ft. container or a truck trailer. This would require a formula to convert tonnage into loading units, of which the standard sizing would determine the wagon types and number of wagons required.

A tool was developed for this purpose and is more fully described in **Appendix B, Section B.8**. Using this tool will help evaluate selected O/D pairs for estimated container volume potential later in this chapter and to apply to the costing model in subsequent chapters.

Simplifying to estimate train frequency and equipment required between O/D pairs, one 40 ft. container is equal to approximately one flat wagon or pocket wagon for a trailer, which in turn is approximately equal to one 40 ft. container in total TEU.

5.2.2 Selection of Routes to Analyze and Model.

To determine costs, one would next have to examine concrete flows between O/D pairs, given the criteria discussed in Chapter 4. The purpose of this step is to reduce the universe of candidate OD pairs to include in the analysis and to ultimately select a route to analyze and model.

The fundamental questions are:

- What are the gross yearly tonnages of the targeted commodities from the data at hand?
- In what loading units would the commodities be transported in?
- Are there intermodal terminals in the origin and destination region?
- What are the tonnages of the targeted commodities on the reverse trip e.g., is there a possibility of transporting loads on the return trip? If so, what are the volumes?
- Are the loads balanced or skewed in either direction?
- What type of railway equipment (wagons) would be needed?
- What wagons have the highest possibility of being loaded in the reverse direction?

- What special infrastructure is needed for loading or unloading?
- Are there terminals at either end of sufficient capacity?
- Will the paths on the infrastructure accommodate long enough trains to achieve a profit, given the costs?
- Can scale be achieved?

5.2.3 The Raw Data

The raw data extracted from the RETRACK project required considerable effort to become useful. The data itself was separated by modes, rail and truck. From that data, it was possible to determine:

- Tonnages by mode and commodity between O/D pairs
- Kilometers between O/D pairs
- Time between O/D pairs for trucks

Data for approximately 3.7 mm O/D pairs on a NUTS3 level were generated for truck tonnage volumes, along with distances between O/Ds, time traveled and 12 types of NST2 commodities that were most likely to be transported in trucks or trailers. Approximately 488,000 O/D pairs were generated for rail tonnages between O/D pairs, also per above.

5.2.4 Characteristics of the Concrete Flows

The criteria discussed in Chapter 4 and data analysis, certain characteristics of the traffic emerged that led to the questions posed above and a more refined route criteria selection.

The initial strategy of this PhD was the premise of traditional heavy, bulk cargo, combined with intermodal traffic would be the train composition of choice between OD pairs. However, patterns detected in the analysis of the data revealed substantial truck traffic between certain O/D pairs.

The criteria premises, as explained in Chapter 4, as regards traffic volumes between certain countries certainly apply in this case, with the exception being that to capitalize on reverse traffic, now transported by trucks, it became obvious that to handle that traffic, it would be necessary to use wagons that could have the trucks and/or truck trailers loaded on them.

Over longer distances, part of the rationale for selecting a route (>500 km), was that rail would become more economical than trucks, as distances increased.

The selection criteria can be summarized below, compiled from the flow chart in Chapter 4.

O/D Pair Characteristics
Corridor Connectivity
Traffic Generating Region
Population
Transport Distances
Bridge Traffic Volume
Balanced Traffic
Economic Clusters
Traffic Type 1
Traffic Type 2
Traffic Type 3
Service Models
Operating
Line Characteristics
Regulatory

Table 8: Flow Chart Checklist Matrix

5.2.5 Initial Origin Destination Pairs Selected

From the analyzed data, the following O/D pairs were initially selected and listed with their characteristics.

Characteristics Initial Selection of O/D Pairs	Countries Traversed	Intermodal Terminals	Sea or Riverports	Distance > 500 Km	Corridors Traversed
Antwerp - Posnan	3	Yes	Yes	984 – 1000	Baltic Adriatic North Sea Baltic
Antwerp - Wroclaw	3	Yes	Yes	904 - 1056	North Sea Baltic
Rotterdam - Posnan	3	Yes	Yes	954 - 1066	Baltic Adriatic North Sea Baltic
Rotterdam - Wroclaw	3	Yes	Yes	874 - 1026	North Sea Baltic
Duisburg - Gothenburg	3	Yes	Yes	961 - 991	Scand-Med North Sea Baltic
Duisburg - Malmo	3	Yes	Yes	746 - 777	Scand-Med North Sea Baltic
Hamburg - Mamo	3	Yes	Yes	400	Scand-Med
Hamburg - Gothenburg	3	Yes	Yes	600 - 611	Scand-Med

Table 9: Selected O/D pairs

5.2.6 Summary of the Rationale for Selected Matrices of OD Pairs

The following origin destination pairs were selected on these criteria:

a. Corridor connectivity
b. Traffic generating
c. Population
d. Transport distances
e. Bridge traffic
f. Traffic balance
g. Areas are an economic cluster
h. Traffic type 1 = Low container rail traffic
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service (operational) models e.g., different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – train lengths
m. Line characteristics – limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature and line segments are electrified.
n. Regulatory ease
o. Ratings – Scale of 1 – lowest to 3 – highest, summed for an approximate relative rating, based on score value

5.2.7 Matrix of Relative Strengths and Weaknesses of O/D Pairs

The chart below illustrates the relative strengths and weaknesses of the O/D pairs, based on the selection criteria. This is a compilation from the notes section at the end of each section, from which the values were taken.

O/D Pair Characteristics	Antwerp - Posnan	Antwerp - Wroclaw	Rotterdam - Posnan	Rotterdam - Wroclaw	Duisburg - Gothenburg	Duisburg - Malmo	Hamburg - Malmo	Hamburg - Gothenburg
Corridor Connectivity	3	3	3	3	3	3	3	3
Traffic Generating Region	1	2	1	3	2	2	1	1
Population	2	3	3	3	2	3	3	3
Transport Distances	3	3	3	3	2	2	1	2
Bridge Traffic Volume	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Balanced Traffic	3	3	1	2	1	1	1	1
Economic Clusters	2	3	3	3	3	3	3	3
Traffic Type 1	2	3	3	3	1	1	1	1
Traffic Type 2	2	2	2	2	3	2	2	2
Traffic Type 3	3	3	3	3	3	3	3	3
Service Models	1	1	1	1	1	1	1	1
Operating	2	2	2	2	2	2	2	2
Line Characteristics	3	3	3	3	3	3	3	3
Regulatory	1	1	1	1	3	3	3	3
Scores	**28**	**32**	**29**	**32**	**29**	**29**	**27**	**28**
Notes Sections	**5.3.1**	**5.3.2**	**5.3.3**	**5.3.4**	**5.3.5**	**5.3.6**	**5.3.7**	**5.3.8**

Table 10: Matrix of Relative Strengths and Weaknesses of O/D Pairs

5.3 Choices of O/D Pairs

5.3.1 Antwerp - Posnan

This combination initially qualified, because of its distance between O/Ds (984 – 1000 km), a seaport, intermodal terminals at each end and average time traveled (30.1 hours).

In the case of Antwerp – Posnan, the total estimated containers are approximately 51.5% of the total truck tonnage, compared to Antwerp – Wroclaw.

NUTS3 Zone 102020101	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Antwerpen - Posnan	8033	901	526	10
Antwerpen - Kaliski	0	0	0	0
Antwerpen - Koninski				0
Antwerpen - Pilski				0
Antwerpen - Leszczynski	962	108	63	1
Subtotal	**8995**	**1009**	**589**	**11**

Table 11: Antwerpen – Posnan, Truck Volume

Secondly, while the return container balance to Antwerp from Posnan is favorable (with a ratio of approximately 16.6% more traffic to Antwerp from Posnan, than the reverse), the balances are good. The actual reverse container count is only 50.4% of Wroclaw.

NUTS3 Zone 102020101	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Posnan - Antwerpen	4348	488	284	5
Kaliski - Antwerpen	2392	268	156	3
Koninski - Antwerpen				0
Pilski - Antwerpen	1629	183	107	2
Leszczynski - Antwerpen	2136	240	140	2
Subtotal	**10505**	**1179**	**687**	**12**

Table 12: Posnan - Antwerpen – Posnan, Truck Volume

Thirdly, although Posnan has five population centers in the neighboring NUTS3 zones, Posnan, Pilski, Kaliski, Koninski and Leszcynski, it has only slightly more than 50% of the total container traffic to Antwerp than Wroclaw to Antwerp.

O/D Pair Total RT	Yearly RT Tons Road	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Cont. Rail	Total RT Cont. All	Orig-Dest Ratio
Antwerpen - Posnan	12381	1389	810	0	**810**	1.847516
Antwerpen - Kaliski	2392	268	156	0	**156**	0
Antwerpen - Koninski	0	0	0	0	**0**	
Antwerpen - Pilski	1629	183	107	0	**107**	0
Antwerpen - Leszczynski	3098	348	203	0	**203**	0.450375
Total	**19500**	**2188**	**1276**	**0**	**1276**	**0.856259**

Table 13: Antwerpen – Posnan, Total Volumes

Antwerp – Posnan Adherence to Criteria

a. Corridor connectivity good; connects with North Sea Baltic corridor
b. Traffic generating rather poor, compared to other O/Ds
c. Population medium
d. Transport distances capitalize on rail
e. Bridge traffic not available or known and will require further study
f. Traffic balance poor
g. Area is an economic cluster
h. Traffic type 1 = moderate container traffic potential to, from and between ports
i. Traffic type 2 = moderate traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities -
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – corridor is well maintained, but Poland limits train lengths to 600 meters
m. Line characteristics – good, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. Much of the corridor is electrified.
n. Regulatory – Fair to poor, as homologation of different locomotives is difficult in Poland, from Germany or Netherlands. Also, Polish infrastructure charges are the highest in Europe and the authorities are inflexible with pricing
o. Ratings – Scale of 1 – lowest to 3 – highest, **score summed for an approximate relative rating, based on score value is 1, the lowest, shared with Hamburg – Gothenburg and Hamburg - Malmo.**

O/D Pair Characteristics	Antwerp - Posnan
Corridor Connectivity	3
Traffic Generating Region	1
Population	2
Transport Distances	3
Bridge Traffic Volume	N/A
Balanced Traffic	3
Economic Clusters	2
Traffic Type 1	2
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	1
Score	28

Table 14: Antwerpen – Posnan, Route Characteristics Rating

Summary

This route has the distance ideal for rail and has a seaport at one end, Antwerp. For what little traffic the route has, the balance in both directions is good. But, Posnan has negligible rail traffic in either direction to Antwerp, plus having only ~50% of the competing Antwerp – Wroclaw route for containers by truck, the traffic level is too low. For those reasons, the route Antwerp – Posnan did not qualify for the initial selection round.

5.3.2 Antwerp - Wroclaw

In the case Antwerp – Wroclaw, the opposite is true. Wroclaw qualified because its four population centers in neighboring NUTS3 economic cluster zones (Wroclaw, Jeleniogorski, Legnicko-Glogowski, Walbrzyski and Zielonogorski), are an average of 980.57 km from Antwerp (in a range from 904 to 1056 kms), and an average trip time of 30.82 hours (range 28.65 to 31.36 hours).

In the case of Antwerp – Wroclaw, the total truck tonnage in the categories likely to be carried in containers or trailers is approximately 2x (197.73%) more than the total truck tonnage, compared to Antwerp – Posnan.

NUTS3 Zone 102020101	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Antwerpen - Wroclaw	4852	514	300	6
Antwerpen - Legnicko-Glogowski	5244	588	343	6
Antwerpen - Zielonogorski	6036	677	395	7
Antwerpen - Jeleniogorsk	1623	182	106	2
Subtotal	**17755**	**1961**	**1144**	**21**

Table 15: Antwerpen – Wroclaw , Truck Volume

Secondly, the return tonnage to Antwerp from Wroclaw is slightly skewed towards Antwerp, with a ratio of 16% more traffic to Antwerp, than the reverse), the actual reverse volume in gross tonnage is 2x that of Posnan.

NUTS3 Zone 102020101	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Wroclaw - Antwerpen	4679	525	306	6
Legnicko-Glogowski - Antwerpen	4779	536	313	6
Zielonogorski - Antwerpen	6995	784	458	9
Jeleniogorski - Antwerpen	4350	488	285	6
Subtotal	**20803**	**2333**	**1362**	**27**

Table 16: Wroclaw - Antwerpen, Truck Volume

Thirdly, Wroclaw has five population centers in the economic cluster NUTS3 zones, Wroclaw, Jeleniogorski, Legnicko-Glogowski, Walbrzyski and Zielonogorski. Of those, all of them have substantial inbound and outbound volumes, that have a nearly even traffic balance in either direction.

O/D Pair Total RT	Yearly RT Tons Road	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Cont. Rail	Total RT Cont. All	Orig-Dest Ratio
Antwerpen - Wroclaw	9531	1069	624	0	**624**	1.036974
Antwerpen - Legnicko-Glogowski	10023	1124	656	0	**656**	1.097301
Antwerpen - Zielonogorski	13031	1461	852	0	**852**	0.862902
Antwerpen - Jeleniogorsk	5973	670	391	0	**391**	0.373103
Total	**38558**	**4324**	**2523**	**0**	**2523**	**0.853483**

Table 17: Antwerpen – Wroclaw, Total Volumes

Antwerp – Wroclaw Adherence to Criteria

a. Corridor connectivity good; connects with North Sea Baltic corridor
b. Traffic generating rather poor, compared to other O/Ds
c. Population high
d. Transport distances capitalize on rail
e. Bridge traffic not available or known and will require further study
f. Traffic balance good
g. Area is an economic cluster
h. Traffic type 1 = substantial container traffic potential to, from and between ports
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities -
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – corridor is well maintained, but Poland limits train lengths to 600 M
m. Line characteristics – good, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. Much of the corridor is electrified.
n. Regulatory – Fair to poor, as homologation of different locomotives is difficult in Poland, from Germany or Netherlands. Also, Polish infrastructure charges are the highest in Europe and the authorities are inflexible with pricing

o. Ratings – **3** on a scale of 1 to 3, based on **score value summed for approximate relative rating is 3, the highest rating.**

Wroclaw has nearly negligible rail traffic to or from Antwerp, however the return truck volume from Wroclaw to Antwerp is substantial and could be a good source of tonnage to the Port of Antwerp.

O/D Pair Characteristics	Antwerp - Wroclaw
Corridor Connectivity	3
Traffic Generating Region	2
Population	3
Transport Distances	3
Bridge Traffic Volume	N/A
Balanced Traffic	3
Economic Clusters	3
Traffic Type 1	3
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	1
Score	32

Table 18: Antwerpen – Wroclaw, Route Characteristics Rating

Summary

This route has approximately twice the traffic of Antwerp – Posnan, the distance is ideal for rail and there is a seaport, Antwerp, at one end. The balance of traffic is good and there is a good population base in Wroclaw. For those reasons, Antwerp – Wroclaw is **qualified** for the initial selection round.

5.3.3 Rotterdam – Posnan

This pair initially qualified, because of its average distance between O/Ds (991 km) and average time traveled (30.47 hours). The range for kilometers is from 954 to 1066 and the driving times range between 29.76 to 31.83 hours.

In the case of Rotterdam – Posnan, the total truck tonnage in the categories likely to be carried in containers is approximately 52.94% of the total truck tonnage, compared to Rotterdam – Wroclaw.

NUTS3 Zone From: 124030305	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Rotterdam - Posnan	16489	1849	1079	21
Rotterdam - Pilski	1248	140	82	1
Rotterdam - Kaliski	3273	327	214	4
Rotterdam - Koninski		0	0	0
Rotterdam - Leszczynski	4821	541	315	6
Subtotal	**25831**	**2857**	**1690**	**32**

Table 19: Rotterdam – Posnan, Truck Volume

Secondly, the return truck tonnage to Rotterdam from Posnan is not very favorable, with only approximately 24.6%, compared to Wroclaw, with 41.54% truck tonnage returning. For Posnan, this means a ratio of 4.06x more traffic from Rotterdam, than the reverse and the actual reverse tonnage is only 35.6% of Wroclaw's.

NUTS3 Zone From: 126040101-108	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Posnan - Rotterdam	4786	537	313	6
Pilski - Rotterdam		0	0	
Kaliski - Rotterdam		0	0	
Koninski - Rotterdam		0	0	
Leszczynski - Rotterdam	1568	176	103	2
Subtotal	**6354**	**713**	**416**	**8**

Table 20: Posnan - Rotterdam, Truck Volume

Thirdly, Posnan has five population centers in the neighboring NUTS3 zones, Posnan, Pilski, Kaliski, Koninski and Leszcynski. Of those, while Kaliski, Leszcynski and Pilski have inbound truck tonnage (25831 annual tons), Kaliski, Koninski and Pilski have no outbound traffic to Rotterdam.

O/D Pair Total RT	Yearly RT Tons Road	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Cont. Rail	Total RT Cont. All	Orig-Dest Ratio
Rotterdam - Posnan	21275	2386	1392	5	**1397**	3.445257
Rotterdam - Pilski	1248	140	82		**82**	
Rotterdam - Kaliski	3273	367	214		**214**	
Rotterdam - Koninski	0	0	0			
Rotterdam - Leszczynski	6389	716	418	1	**419**	3.074617
Total	**32185**	**3609**	**2106**	**6**	**2112**	**4.065313**

Table 21: Rotterdam – Posnan, Total Volumes

Lastly, Posnan has negligible rail traffic in either direction, with only 85.5 tons recorded in the database for Posnan – Rotterdam traffic.

Rail - NUTS3 Zone From: 126040101-108	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Posnan - Rotterdam	75	8	5	0.1
Kaliski - Rotterdam				
Leszczynski - Rotterdam	10.5	1.17	1	0.02
Subtotal	**85.5**	**9.17**	**6**	**0.12**

Table 22: Posnan - Rotterdam, Rail Volumes

Rotterdam – Posnan Adherence to Criteria

a. Corridor connectivity good and connects with the North Sea Baltic corridor
b. Traffic generating rather high, compared to other O/Ds
c. Population high
d. Transport distances capitalize on rail
e. Bridge traffic not available or known and will require further study
f. Traffic balance skewed towards Wroclaw from Rotterdam, but substantial reverse traffic to convert to rail
g. Area is an economic cluster

h. Traffic type 1 = substantial container traffic potential to, from and between ports
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – corridor is well maintained, but Poland limits train lengths to 600 meters
m. Line characteristics – good, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. Much of the corridor is electrified.
n. Regulatory – Fair to poor, as homologation of different locomotives is difficult in Poland, from Germany or Netherlands. Also, Polish infrastructure charges are the highest in Europe and the authorities are inflexible with pricing
o. Ratings – Scale of 1 – lowest to 3 – highest, based on **score summed for an approximate relative rating is 2, which is moderate or medium**

O/D Pair Characteristics	Rotterdam - Posnan
Corridor Connectivity	3
Traffic Generating Region	1
Population	3
Transport Distances	3
Bridge Traffic Volume	N/A
Balanced Traffic	1
Economic Clusters	3
Traffic Type 1	3
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	1
Score	29

Table 23: Rotterdam – Posnan, Route Characteristics Rating

Summary

As with Antwerp – Posnan, the number of containers moved by truck from Rotterdam to Posnan is only ~50% of the Rotterdam – Wroclaw route. The balance of traffic is approximately four-to-one, skewed Rotterdam to Posnan, with only 25% return traffic. For those reasons, Rotterdam – Posnan does **not qualify** for the initial selection round**.**

5.3.4 Rotterdam – Wroclaw

Wroclaw is considered because its five population centers in neighboring NUTS3 economic cluster zones (Wroclaw, Jeleniogorski, Legnicko-Glogowski, Walbrzyski and Zielonogorski), are an average of 966.08 km from Antwerp (in a range from 874 to 1026 kms) and an average trip time of 30.82 hours (range 29.28 to 31.9 hours).

In the case of Rotterdam – Wroclaw, the total truck tonnage in the categories likely to be carried in containers is 52.94% more and actual containers are approximately 4.64x more, compared to Rotterdam – Posnan.

NUTS3 Zone From: 124030305	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Rotterdam - Wroclaw	14195	1592	929	18
Rotterdam - Legnicko-Glogowski	9061	1016	593	11
Rotterdam - Walbrzyski	2279	256	149	2
Rotterdam - Zielonogorski	13426	1506	878	17
Rotterdam - Jeleniogorski	3992	448	261	5
Total	**42953**	**4818**	**2810**	**53**

Table 24: Rotterdam – Wroclaw, Truck Volume

Secondly, the return tonnage to Rotterdam from Wroclaw is 41.54% truck tonnage returning to Rotterdam, with a ratio of 58.46% more traffic to Wroclaw, than the reverse), the actual reverse tonnage in gross tonnage to Rotterdam is 2.81x that of Posnan.

NUTS3 Zone To: 124030305	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Wroclaw - Rotterdam	2370	266	155	3
Legnicko-Glogowski - Rotterdam	6100	683	399	7
Walbrzyski - Rotterdam	0	0	0	0
Zielonogorski - Rotterdam	5007	562	328	6
Jeleniogorski - Rotterdam	4367	490	286	5
Subtotal	**17844**	**2001**	**1168**	**21**

Table 25: Wroclaw - Rotterdam, Truck Volume

Thirdly, Wroclaw has five population centers in the economic cluster NUTS3 zones, Wroclaw, Jeleniogorski, Legnicko-Glogowski, Walbrzyski and Zielonogorski. Of those, all of them have substantial inbound and outbound volumes, although with traffic balanced approximately 2.5:1

in the direction towards Wroclaw. The exception is Jeleniogorski, which has a ratio of 9.39% more reverse traffic to Rotterdam, than inbound, which is 91.4% of the traffic for this O/D pair.

O/D Pair Total RT	Yearly RT Tons Road	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Cont. Rail	Total RT Cont. All	Orig-Dest Ratio
Rotterdam - Wroclaw	16565	1746	1018	62	1080	6.386392
Rotterdam - Legnicko-Glogowski	15161	1700	992	63	1055	1.64328
Rotterdam - Walbrzyski	2279	256	149	0	149	
Rotterdam - Zielonogorski	18433	2067	1206	0	1206	2.681446
Rotterdam - Jeleniogorski	8359	937	547	0	547	0.914129
Total	**60797**	**4883**	**9766**	**125**	**4037**	**2.513829**

Table 26: Rotterdam – Wroclaw, Total Volumes

Wroclaw has nearly negligible rail traffic to Rotterdam, however, the analysis shows approximately 1904 annual tons inbound from Rotterdam, with approximately 2 containers per week.

Rail From: 124030305	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Rotterdam - Wroclaw	940.75	106	62	1
Rotterdam - Legnicko-Glogowski	963.01	108	63	1
Rotterdam - Walbrzyski				
Subtotal	**1903.76**	**214**	**125**	**2**

Table 27: Rotterdam - Wroclaw, Rail Volumes

Rotterdam – Wroclaw Adherence to Criteria

a. Corridor connectivity good and connects with the North Sea Baltic corridor
b. Traffic generating rather high, compared to other O/Ds
c. Population high
d. Transport distances capitalize on rail
e. Bridge traffic not available or known and will require further study
f. Traffic balance skewed towards Wroclaw from Rotterdam, but substantial reverse traffic to convert to rail
g. Area is an economic cluster
h. Traffic type 1 = substantial container traffic potential to, from and between ports
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – corridor is well maintained, but Poland limits train lengths to 600 meters
m. Line characteristics – good, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. Much of the corridor is electrified.
n. Regulatory – Fair to poor, as homologation of different locomotives is difficult in Poland, from Germany or Netherlands. Also, Polish infrastructure charges are the highest in Europe and the authorities are inflexible with pricing
o. Ratings – Scale of 1 – lowest to 3 – highest, **scores summed for an approximate relative rating, it is a 3, which is the highest rating**

O/D Pair Characteristics	Rotterdam - Wroclaw
Corridor Connectivity	3
Traffic Generating Region	3
Population	3
Transport Distances	3
Bridge Traffic Volume	N/A
Balanced Traffic	2
Economic Clusters	3
Traffic Type 1	3
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	1
Score	32

Table 28: Rotterdam – Wroclaw, Route Characteristics Rating

Summary

This route has more than 52% of truck traffic moving in containers and 4.6x raw count containers moving Rotterdam – Wroclaw. In addition, the balance of traffic is favorable, due to the 59%/41% traffic balance from a seaport. Due to the above, plus the potential for outbound return traffic to Rotterdam to be shifted from truck to rail, the route Rotterdam – Wroclaw is **qualified** for the initial selection round.

5.3.5 Duisburg – Gothenburg

Gothenburg was initially included for these reasons. Its NUTS3 area is the "Vastra Gotalands lan" (county, in English parlance), that includes the Port of Gothenburg and is an economic cluster by itself. The distance from Duisburg economic cluster ranges from 961 to 991 km, with an estimated driving trip time of 30.86 to 31.1667 hours.

NUTS3 Zone From: 107100102	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Duisburg, Kreisfreie Stadt - Vastra Gotalands lan	6520	731	427	**8**
Subtotal	**6520**	**731**	**427**	**8**

Table 29: Duisburg – Gothenburg, Truck Volume

NUTS3 Zone From: 129020302	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Vastra Gotalands lan - Duisburg, Kreisfreie Stadt	1037	116	68	**1**
Subtotal	**1037**	**116**	**68**	**1**

Table 30: Gothenburg - Duisburg, Truck Volume

Duisburg itself is a large railway hub with substantial terminal infrastructure and is located at the confluence of the Rhine and Ruhr Rivers. It is within the Ruhr Metropolitan area and is one of the densest industrial areas in Europe, known as the Ruhr Valley.

Secondly, the actual truck traffic between these ODs and the rail traffic northbound to Sweden is not high. Between the Duisburg economic cluster, consisting of the cities of Dusseldorf, Duisburg, Essen, Kleve, Krefeld-Kreisfeie Stadt, Mettman, Monchengladbach, Mulheim, Oberhausen, Remscheid, Solingen, Wuppertal, Viersen and Wesel to Vastra Gotalands lan (the Gothenburg area, including the port), there are only 6246 tons moving over this route by rail, just for goods that have a high probability of being containerized. However, the return trip by rail linking this OD region is quite substantial at 122,055 tons annually.

Rail From: 107100102	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Duisburg, Kreisfreie Stadt - Vastra Gotalands lan	6246.61	701	409	**8**
Subtotal	**6246.61**	**701**	**409**	**8**

Table 31: Duisburg - Gothenburg, Rail Volumes

Rail From: 129020302	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Vastra Gotalands lan - Duisburg, Kreisfreie Stadt	122055.39	13688	7985	159
Subtotal	**122055.39**	**13688**	**7985**	**159**

Table 32: Gothenburg - Duisburg, Rail Volumes

Nevertheless, the traffic is skewed too heavily in one direction, with nearly 95% of the rail traffic moving in the direction of Germany and only approximately 5% moving towards Gothenburg. This can be partially explained by the traffic movement from other origins, likely moving by either Short Sea Shipping or by truck using ferry boats from the ports of Lubeck, Kiel, Rostock and others to the Swedish ports of Trelleborg and Ystad.

O/D Pair Total RT	Yearly RT By Mode	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Cont. Rail	Total RT Cont. All	Orig-Dest Ratio
Duisburg - Vastra Gotalands lan - Truck	**7557**	**847**	**495**	**8394**	**8889**	**6.287367406**
Duisburg - Vastra Gotalands lan - Rail	**128302**	**1083**	**682**	**0**	**682**	**0.948821515**
Total	**135859**	**1930**	**1177**	**8394**	**9571**	**6.626501728**

Table 33: Duisburg – Gothenburg, Total Volumes

Duisburg – Gothenburg Adherence to Criteria

a. Corridor connectivity good and connects with the Scan-Med and North Sea Baltic corridor
b. Traffic generating somewhat substantial for rail from Gothenburg, but not much for truck; rather low
c. Population medium
d. Transport distances capitalize on rail
e. Bridge traffic not available or known and will require further study

f. Traffic balance poor – heavily skewed towards Germany from Gothenburg by rail and truck, but not much reverse traffic
g. Area is an economic cluster
h. Traffic type 1 = insubstantial container traffic potential to, from and between ports, as it's a one-way trip. Poor.
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – excellent, as the corridor is well maintained, and allows train lengths from 750 meters DE to 850 meters DK
m. Line characteristics – excellent, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. The line segments are electrified.
n. Regulatory – Good, although homologation of different locomotives could be problematic between three different countries
o. Ratings – Scale of 1 – lowest to 3 – highest, **scores summed for an approximate relative rating, it is a 2, which is a moderate or medium t rating**

O/D Pair Characteristics	Duisburg - Gothenburg
Corridor Connectivity	3
Traffic Generating Region	2
Population	2
Transport Distances	2
Bridge Traffic Volume	N/A
Balanced Traffic	1
Economic Clusters	3
Traffic Type 1	1
Traffic Type 2	3
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	3
Score	29

Table 34: Duisburg – Gothenburg, Route Characteristics Rating

Summary

The traffic between Duisburg and Gothenburg going north is not substantial, however the return trip with containers by rail is very high. This can be partly explained by inbound short sea shipping. However, the balance of traffic is too heavily skewed from Gothenburg to Duisburg in a 20:1 ratio. For this reason, Duisburg – Gothenburg does **not qualify** for the initial selection round.

5.3.6 Duisburg - Malmo

Malmo was initially included for several reasons. Its NUTS3 area is the “Skane lan” region that includes the Port of Malmo and is an economic cluster by itself. Its location is at the extreme southern tip of the Swedish land mass and is also directly across the Oresund body of water from the Copenhagen area. The two large metropolitan areas are separated by only 30 km and linked by the Oresund Bridge, which carries both rail and road traffic.

However, for the purposes of this analysis, Copenhagen will not be considered as a weighing factor because the Danish side is already amply served by the Port of Copenhagen, located in the Osterport area of the city and the rail intermodal terminal at Hoje Taastrup (operated by Deutsche Bahn), located approximately 25 km west of the city.

In addition, the truck tolls charged in either direction over the bridge are quite substantial, reducing or nullifying any cost savings gained through services that are substantially less expensive in Malmo, than in Denmark.

The distance from the Duisburg economic cluster ranges from 746 to 777 km, with an estimated driving trip time of 26.33 to 28.2166 hours.

Duisburg itself is a large railway hub with substantial terminal infrastructure and is located at the confluence of the Rhine and Ruhr Rivers. It is within the Ruhr Metropolitan area and is one of the densest industrial areas in Europe, known as the Ruhr Valley.

Secondly, while the actual truck traffic between these O/Ds is not high, the rail traffic northbound to Sweden is very substantial. Between the Duisburg economic cluster, consisting of the cities of Dusseldorf, Duisburg, Essen, Kleve, Krefeld-Kreisfeie Stadt, Mettman, Monchengladbach, Mulheim, Oberhausen, Remscheid, Solingen, Wuppertal, Viersen and Wesel to Skane lan (Malmo area, including the port), there are only 8263 tons moving over this route by truck.

NUTS3 Zone From: 107100102	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Duisburg, Kreisfreie Stadt - Skane Lan	8263	927	541	**10**
Subtotal	**8263**	**927**	**541**	**10**

Table 35: Duisburg – Malmo, Truck Volume

The return volume by truck from the Malmo area towards Duisburg is even poorer, at 1093 tons annually, an approximately 8:1 ratio towards Malmo.

NUTS3 Zone From: 129020302	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Skane Lan - Duisburg, Kreisfreie Stadt	1093	123	72	**1**
Subtotal	**1093**	**123**	**72**	**1**

Table 36: Malmo -Duisburg, Truck Volume

Thirdly, however, the rail traffic for goods that have a high probability of being containerized is 420,484 tons annually. The return trip southbound by rail linking this O/D region is still substantial at 86,106 tons annually, although the balance is poor at only 20.47% of the total rail traffic, an approximately 5:1 ratio skewed towards the direction of Malmo. Nevertheless, the sheer volume of rail traffic moving into Malmo from Duisburg and the Ruhr Valley area cannot be dismissed.

Rail From: 107100102	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Duisburg, Kreisfreie Stadt - Skane Lan	**420484.2**	47157	27508	**550**
Subtotal	**420484.2**	**47157**	**27508**	**550**

Table 37: Duisburg – Malmo, Rail Volume

Rail From: 129020302	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Skane Lan - Duisburg, Kreisfreie Stadt	86106	9657	5633	**112**
Subtotal	**86106**	**9657**	**5633**	**112**

Table 38: Duisburg – Malmo, Rail Volume

O/D Pair Total RT	Yearly RT By Mode	Yearly RT TEU Road/Rail	Yearly RT Container Road	Yearly RT Container Rail	Total RT Container All	Orig-Dest Ratio
Duisburg, Kreisfreie Stadt-Skane Lan - Truck	9356	1050	613	0	613	7.559926807
Duisburg, Kreisfreie Stadt-Skane Lan - Rail	506590.2	56814	0	33141	33141	4.883332637
Total	515946.2	57864	613	33141	33754	4.916882533

Table 39: Duisburg – Malmo, Total Volumes

The business case has its positives. Due to the region's role in feeding other regions in Sweden immediately to the east, middle and north of the country, because traffic volumes pass through, both from port and rail traffic, this O/D pair merits further study.

Duisburg – Malmo Adherence to Criteria

a. Corridor connectivity good and connects with the Scan-Med and North Sea Baltic corridor
b. Traffic generating very substantial for rail, especially Duisburg to Malmo and less so returning to Duisburg, but still substantial. There is not much volume for containers by truck to Malmo and even less traffic returning to Duisburg compared to other O/Ds
c. Population in the Malmo area medium-high
d. Transport distances capitalize on rail
e. Bridge traffic not available or known and will require further study
f. Traffic balance poor – heavily skewed towards Malmo from Duisburg by rail and truck, but not as much reverse traffic by rail and even less by truck
g. Area is an economic cluster
h. Traffic type 1 = substantial container traffic potential from Duisburg to Malmo, however, it is a one-way trip. Poor.
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability

p. Operating models – excellent, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. The line segments are electrified.

l. Line characteristics – good, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. Much of the corridor is electrified.

m. Regulatory – Good, although homologation of different locomotives could be problematic between three different countries

n. Ratings – Scale of 1 – lowest to 3 – highest, **score summed for an approximate relative rating, it is a 2, which is a moderate or medium rating**

O/D Pair Characteristics	Duisburg - Malmo
Corridor Connectivity	3
Traffic Generating Region	2
Population	3
Transport Distances	2
Bridge Traffic Volume	N/A
Balanced Traffic	1
Economic Clusters	3
Traffic Type 1	1
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	3
Score	29

Table 40: Duisburg – Malmo, Route Characteristics Rating

Summary

Similar to Duisburg – Gothenburg, this route has little traffic moving northbound and even less interesting, with traffic terminating in Malmo, already substantially served by intermodal terminals and the Port of Copenhagen on the Danish side. By truck, the ratio southbound to northbound is approximately 8:1 and the ratio by rail to Malmo from Duisburg improves 5:1.

The Malmo area, being in the far southwestern part of Sweden, feeds much of the north of Sweden from this area.

For these reasons, Duisburg – Malmo is **conditionally qualified** for the initial selection round.

5.3.7 Hamburg - Malmo

Hamburg to Malmo was considered for the following reasons. Both regions are production and consumption areas. They both have large populations in their respective metropolitan areas that consume. Both have large ports, with traffic radiating to and from them in multiple directions. They have the rail terminal infrastructure necessary for intermodal (CT) traffic for trucks, trailers, swap bodies and containers.

The distance from the Hamburg economic cluster to Malmo is approximately 400 km, with an estimated driving trip time of 8.516 hours.

The truck tonnage volume between these two regions is fairly substantial at 23,166 between Hamburg and Malmo and 13,752 in the direction from Malmo to Hamburg. That translates to an approximately 63% proportion towards Malmo and 37% on the return trip to Hamburg.

NUTS3 Zone From: 107060000	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Hamburg - Skane Lan	**23166**	**2598**	**1516**	**30**
Subtotal	**23166**	**2598**	**1516**	**30**

Table 41: Hamburg – Malmo, Truck Volume

Curiously, the rail traffic with a high probability of being in a container, in either direction between these two points, is negligible. In an effort to detect more traffic, the geographic ranges of the search expanded to the Bremen area and port, with no positive result.

NUTS3 Zone From: 129020302	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Skane Lan - Hamburg	**13752**	**1542**	**900**	**18**
Subtotal	**13752**	**1542**	**900**	**18**

Table 42: Malmo - Hamburg, Truck Volume

The low volume of rail freight is likely because both nodes are large seaports, the distances between them not large, nor is driving time long and is easily accomplished within a day.

O/D Pair Total RT	Yearly RT Tons Road	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Cont. Rail	Total RT Cont. All	Orig- Dest Ratio
Hamburg -Skane Lan	**36918**	**4140**	**2416**	**0**	**2416**	**0.627499**
Total	**36918**	**4140**	**2416**	**0**	**2416**	**0.372501**

Table 43: Hamburg – Malmo, All Volume

Hamburg – Malmo Adherence to Criteria

a. Corridor connectivity good and connects with the Scan-Med corridor
b. Traffic generating not high for truck from Hamburg to Malmo and less so returning to Hamburg. For rail, reasons are that both origin and destination are served by ports, distances are short and distribution is local from the ports. Rail non-existent.
c. Population in Malmo and Hamburg is high
d. Transport distances are short and rail cannot capitalize on the short segment
e. Bridge traffic not available or known and will require further study
f. Traffic balance poor - skewed towards Malmo from Hamburg by truck and even less Malmo to Hamburg by truck. Due to short distance, no measurable rail traffic in the container categories
g. Areas are an economic cluster
h. Traffic type 1 = Low container rail traffic potential from Hamburg to Malmo, and what little there may be, it is a one-way trip. Poor.
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities likely low, due to seaports and merely local distribution
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – excellent, as corridor is well maintained and allows train lengths from 750 M DE to 850 M DK
m. Line characteristics – excellent, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. The line segments are electrified.

n. Regulatory – Good, although homologation of different locomotives could be problematic between 3 different countries
o. Ratings – Scale of 1 – lowest to 3 – highest, **score summed for an approximate relative rating, it is a 1, which is a low rating**

O/D Pair Characteristics	Hamburg - Malmo
Corridor Connectivity	3
Traffic Generating Region	1
Population	3
Transport Distances	1
Bridge Traffic Volume	N/A
Balanced Traffic	1
Economic Clusters	3
Traffic Type 1	1
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	3
Score	27

Table 44: Hamburg – Malmo, Route Characteristics Rating

Summary

This O/D pair has a large concentration of logistics activity at both ends, with a ratio of traffic 63% towards Malmo and 37% towards Hamburg. However, the rail traffic in containers is negligible, due to the short distances between the cities easily reached within a day, with no stops in either direction.

For these reasons, Hamburg – Malmo **does not qualify** for the initial selection round.

5.3.8 Hamburg - Gothenburg

Hamburg to Gothenburg is being considered for several reasons, much the same as Hamburg. Both regions are both production and consumption areas. They both have populations in their respective metropolitan areas that consume. Both are large ports, with traffic radiating to and from them in multiple directions. They have the rail terminal infrastructure necessary for intermodal (CT) traffic for trucks, trailers, swap bodies and containers.

In this case, the difference between Hamburg and Gothenburg is the distance. The theory is that due to a longer driving distance and time, a truck trip would not be complete within a day, given driving time regulations. In addition, there is another nearby economic cluster region known as “Jonkopings lan”, which is not far to the east and adjacent to the Gothenburg region. Analysis with the combined traffic volume from both regions could result in a business case.

The distance from Hamburg economic cluster to “Vastragotaland lan” (the Gothenburg region) and the “Jankopings lan” region ranges from 600 to 611 km, with an estimated driving trip time of 12.16 to 12.45 hours.

The truck traffic volume between Hamburg and the Gothenburg area is approximately 20,320 tons annually and combined with the Jankopings lan region, with 5932 tons, the tonnage is 26,252. The return trips are 12,370 and 3727 tons, respectively.

NUTS3 Zone From: 107060000	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Hamburg - Vastra Gotalands lan	20320	2279	1329	26
Hamburg - Jonkopings lan	5932	665	388	7
Subtotal	**26252**	**2108**	**1717**	**33**

Table 45: Hamburg – Gothenburg, Truck Volume

That is a ratio of approximately 62% towards Gothenburg and 38% to Hamburg. From Hamburg to Jankopings lan, the ratio is similar, with 61.4% from Hamburg and 38.6% towards Hamburg. With the traffic combined, the ratio is duplicated with 62% and 38%, respectively.

NUTS3 Zone From: 129020302	Yearly Tonnage	Yearly TEU	Yearly Containers	Weekly Containers
Vastra Gotalands lan - Hamburg	12370	1387	809	39
Jonkopings lan - Hamburg	3727	418	244	4
Subtotal	**16097**	**1292**	**7752**	**43**

Table 46: Gothenburg – Hamburg, Truck Volume

Surprisingly, the rail traffic is negligible in both directions for the commodities carried in a container. Expanding the boundaries of the immediate Hamburg area did not yield additional traffic. The low volume of rail freight is likely because both nodes are large seaports, the distances between them are not large, nor is driving time overly long and easily accomplished, either with relay drivers engaged enroute and/or the same driver, but with rest stops.

O/D Pair Total RT	Yearly RT Tons Road	Yearly RT TEU Road	Yearly RT Cont. Road	Yearly RT Containers Rail	Total RT Containers All	Orig-Dest Ratio
Hamburg - Vastra Gotalands lan	32690	3666	2139	0	**2139**	0.77192
Hamburg - Jonkopings lan	9659	1083	632	0	**632**	0.22808
Total	**42349**	**4749**	**2771**	**0**	**2771**	**0.61317**

Table 47: Hamburg - Gothenburg, All Volume

Hamburg – Gothenburg Adherence to Criteria

a. Corridor connectivity good and connects with the Scan-Med corridor
b. Traffic generating not high for truck from Hamburg to Gothenburg area and less so returning to Hamburg, though combined, higher than Hamburg - Malmo. For rail (none measured, reasons are that both origin and destination are served by ports, distances are short and distribution is local from the ports.
c. Population in Gothenburg medium and Hamburg is high
d. Transport distances are relatively short and rail cannot capitalize on the short segment
e. Bridge traffic not available or known and will require further study
f. Traffic balance poor - skewed towards Gothenburg from Hamburg by truck and even less Gothenburg to Hamburg by truck. Due to short distance, no measurable rail traffic in the container categories
g. Areas are an economic cluster

h. Traffic type 1 = Low container rail traffic potential from Hamburg to Gothenburg. Poor.
i. Traffic type 2 = traffic volume in stable sectors, low value, time sensitivity and/or bulk commodities likely low, due to seaports and merely local distribution
j. Traffic type 3 = many traffic combinations possible, due to corridor density
k. Service models fair to poor, due to 3 different voltages, frequencies, signaling systems and locomotive interoperability
l. Operating models – excellent, as corridor is well maintained and allows train lengths from 750 M DE to 850 M DK
m. Line characteristics – excellent, with minimal limiting infrastructure w.r.t weight & dimensions of rolling stock. Grades & curvature not severe. The line segments are electrified.
n. Regulatory – Good, although homologation of different locomotives could be problematic between 3 different countries
o. Ratings – Scale of 1 – lowest to 3 – highest, **score summed for an approximate relative rating, it is a 1, which is low.**

O/D Pair Characteristics	Hamburg - Gothenburg
Corridor Connectivity	3
Traffic Generating Region	1
Population	3
Transport Distances	2
Bridge Traffic Volume	N/A
Balanced Traffic	1
Economic Clusters	3
Traffic Type 1	1
Traffic Type 2	2
Traffic Type 3	3
Service Models	1
Operating	2
Line Characteristics	3
Regulatory	3
Score	28

Table 48: Hamburg – Gothenburg, Route Characteristics Rating

Summary

The general ratio of traffic from Hamburg to Gothenburg is approximately 62% and 38% in the opposite direction. The low volume of freight by rail and the low potential can likely be explained by the short distances between the nodes and the possibility of traffic moving by short sea shipping.

For these reasons, Hamburg – Gothenburg does **not qualify** for the initial selection round.

5.4 Preliminary Case Scenario Criteria

After analysis of the traffic data from the previous section, ***"Empirical Use of the Cost Model"***, it was now possible to draw the tonnages, distances, categories of commodities transported, modes, transit times between points throughout Europe. Filtering data by the criteria of >500 km, NST/R code commodities most likely to be transported in trucks or containers, between population, production, consumption centers, ports and terminals or any qualifying combination, based on criteria established in Chapter 4, gave an approximate indication of those qualifying tonnages between O/D pairs. From those filters, O/D pair selections were made.

With some indicative tonnages of traffic flow between selected OD pairs as a basis for revenue projections, a cost model could now be developed from the data. This model will take the form of a cost simulation spreadsheet that includes the core category elements of an RU's financial structure, such as revenue, fixed and variable costs.

Because the focus is on commodities likely to be transported in containers or truck trailers as the loading units to be transported, pricing of bulk, chemical, timber, grains, ores, etc. will not be addressed, though through the underlying design, there will be a provision built into the cost simulation spreadsheet for this feature in later iterations and for further research.

The model takes the approach of cases, representing certain path and rolling stock combinations, subject to territory limitations.

5.5 Base Cases, Parameters and Descriptions

For cases 1 to 4:

Line Haul – Intermodal
Pocket Wagons: 17
Pocket Wagon Trailer Capacity: 2 each x 17 = 34 trailers
Load Factor: 80%
Frequency of Trains per Month: 8 round trips per train
Maximum train length: 600 meters

Cases 1 – 4 represent the O/D pairs presented in the **5.2 Traffic Flows** section and assume a balance of traffic (also known as "cycle"), since pocket wagons accommodating trailers will be used. The possibility of attracting reverse trips from freight forwarders, shippers and trucking firms makes this option realistic. These proposed scenarios were confirmed through Delphi sources as a sound strategy.

For cases 5a – 8a:

Line Haul – Intermodal Trip Segments by Rail
Pocket Wagons: 20
Pocket Wagon Trailer Capacity: 2 each x 20 = 40 trailers
Load Factor: 80%
Frequency of Trains per Month: 8 round trips per train
Maximum train length: 600 meters

Cases 5 – 8 were added because Poland restricts the length of trains to 600 meters, including the locomotive, considerably diminishing the scale advantages of rail. In discussions with Delphi sources[i], the possibility of using the existing terminal at Forst (Cottbus) in Germany and located at the border of Poland, came into focus. The difference between the direct operation of trains into either Posnan or Wroclaw is that longer trains would operate to or from either Antwerp or Rotterdam and then trailers would transfer to truck for the relatively short distance, 174 km, 2.5 hours driving time and 203 km, 3 hours driving time, to or from either Posnan or Wroclaw, respectively. Since the transfer cost of the loading units would be incurred anyway, net, the terminal would have an offsetting effect on the overall cost. The trucking firms conducting the transport to/from Forst – Posnan or Wroclaw would certainly have to be paid and the assumption is that it would be at a rate normally charged for a truck trip and blended into the rail rate. (In reality, it's highly probable that a volume rate would be negotiated, further offsetting the additional truck segment cost). For the purposes of pricing to the customer, the same rate would apply[ii], as if the train were to originate or terminate in Poland.

The trucking segments are described below.

For cases 5b – 8b:

Truck Haul – Intermodal Trip Segment by Road
Pocket Wagons: 20
Pocket Wagon Trailer Capacity: 2 each x 20 = 40 trailers
Load Factor: 80%
Frequency of Truck Trips per Month: 8 round trips per trailer
Maximum train length: N/A

Initially, in the simulation model, the same revenue per km was used, as if the trip were to travel completely over rail. The reason for this is to offer a "through rate", to customers (likely for this service, they would be logistics or trucking firms), and either have them complete the final trip by a credit towards the customer using their own trucking resources at their reduced costs or by subcontracting the short Polish segment to trucking firms, who are not the customer). The simulation will determine whether the revenue from longer trains will offset the increased price of the final trip segments by truck. In all cases, a base load factor of 80% is applied, however, that figure can be amended using the slide bars located at the top of each case scenario tab in the spreadsheet. (In an earlier version of the model, the *"Revenue Scenarios"* tab of the spreadsheet could also be used to test different scenarios, but has been deactivated, through refinement; it is simply easier for the researcher to select different scenario combinations from the same case scenario tab.)

However, in the latest iteration of the simulation model, the capability to increase the truck rate by a selected percentage of the rail rate was added to test scenarios in which the truck rate is likely substantially higher than the rail rate. With this refinement, the cost simulation model can now more realistically respond to a dynamic market.

By way of example, if the cost by truck over the short segments to/from Poland is 20% greater, then the truck cost for those segments would be the rail rate per loading unit X 1.20 and similarly, the revenue charged for that portion of the route segment to/from Poland would be the rail rate per loading unit X 1.20. In that way, the increased costs for the truck operated segment would be blended with the total cost for operations over the trip segment and the revenue charged for that segment operated by truck would also be the rail rate per loading unit X 1.20.

For Cases 5 – 8, this method is how revenues and costs were calculated and the financial results reflect this methodology.

In all cases, reverse trip revenue is achieved, using pocket cars loaded with trailers on the return trip, with the same load factor of 80%. To clarify, in all cases, 100% of the 80% load factor (or whatever load factor is selected), would also reflect the number of return trailers. [56]

5.5.1 Other Assumptions

Other assumptions are that there will be two trip frequencies per week for each O/D pair, based on the advice of Delphi sources that any schedule of less than two trains per week offered to the market would not be interesting, as freight forwarders and trucking firms need to have a consistent schedule to offer and market.[57] Another factor is that the actual shippers may not have the facilities to accumulate an entire week (or longer), of production and/or material

[56] There is a provision programmed in that will allow additional trailers to be added by truck only to/from Cottbus Germany and the O/D pair in Poland, in case there is additional traffic to be gained for that short segment. The purpose of this, from an RU's perspective, is to build scale and the opportunity to capture more truck traffic to add to the longer trains possible within Germany and later, Belgium and the Netherlands.

[57] Per discussions with Mr. Steven Archer, President of Baltic Rail Express,

shipments at their sites and must ship or turn inventory to give themselves room to physically operate. The number of trains for each month over the three-year projection span can be adjusted in **Row 14, *"Trainset Trips per Month"*** of each case scenario worksheet tab from **Cases 1 – 4** and **Row 16** for **Cases 5 - 8**. After the profit (or loss) is calculated, the model will help determine the optimum trip combination.

5.5.2 Analysis Products

After the profit (or loss) is calculated, the model will help determine the optimum trip combination. The overview products from the analysis will be:

- Profit
- Breakeven
- Optimal combinations between rate per kilometer, wagons and load factor, given costs ***within*** each case scenario, expressed as NPV and IRR values
- Optimal case scenarios for all O/D pair(s) analyzed, expressed as NPV and IRR values

The assumptions of this analysis can be found in **Chapter 6 – Financial and Risk Analysis** and within **Appendix B – Cost Simulation Model**.

5.6 Preliminary Financial Analysis

The preliminary analysis in this section is intended to establish a *baseline* to gauge financial performance and will merely *serve as a starting point, not as a final financial evaluation and conclusion* of **Cases 1 – 8**. The more refined analyses are in **Chapter 6 – Financial and Risk Analysis**.

For Cases 1 – 4, based on the movement in each direction of 17 wagons, containing 34 trailers (2 trailers for each wagon), at an 80% load factor, (about 27 trailers), the preliminary resulting financials of this case are, as follows, for each case.

5.6.1 Case 1 - Rotterdam - Wroclaw

Based on the movement in each direction of 17 wagons, containing 34 trailers (2 trailers for each wagon), at an 80% load factor, (about 27 trailers), the resulting financials of this case would be an overall profit over three years of €694.434.

The first year starts out with a minimal profit of €178.015, but that figure does not consider any initial startup costs and capital infusion. It is simply an indicative figure to gauge overall operational profit. For years 2 and 3, the profit increases substantially to €246.142 and €225.278, in part, due to the assumption of built-in inflationary increases for both revenue and expenses.

5.6.2 Case 2 - Antwerp - Wroclaw

Based on the movement in each direction of 17 wagons, containing 34 trailers (2 trailers for each wagon), at an 80% load factor, (about 27 trailers) at a rate of €.90, the resulting financials of this case would be a gain of over €5.876.128 over three years.

The first year's operations nets €1.748.955. Years two and three accrue gains of €1.804.687and €2.322.485, respectively.

Based on these projections, this case should be pursued.

5.6.3 Case 3 – Rotterdam - Posnan

Based on the movement in each direction of 17 wagons, containing 34 trailers (2 trailers for each wagon), at an 80% load factor, (about 27 trailers), the resulting financials of this case would be a profit of €911.257, achieved over three years.

As with the first year of Case 1, the RU starts out with a minimal profit of €248.895, but that figure does not consider any initial startup costs and capital infusion, if needed. From there, years two and three yield profits of €319.148 and €343.213, respectively. The projected profitability is partly due to inflationary increases built into the model for both revenue and expenses. This case will be pursued.

5.6.4 Case 4 - Antwerp - Posnan

Based on the movement in each direction of 17 wagons, containing 34 trailers (2 trailers for each wagon), at an 80% load factor, (about 27 trailers), the resulting financials of this case would be €786.860, accumulated over three years.

As in Case 2, the first year's operations incur a slight loss of -€1127, with years two and three achieving a profit of €417,190 and €370.796, respectively.   The projected profitability is partly due to inflationary increases built into the model for both revenue and expenses.

5.6.5 Train Length Discussion for Cases 5 - 8

Cases 5 – 8 were developed due to the general restriction on train lengths in Poland, which are 600 meters, including the locomotive, as mentioned above. This is too short to achieve any scale and contributes to the generally mediocre profitability of Cases 1 – 4. (This is also a problem in the Netherlands and Belgium, where train lengths are restricted to 590 - 690 meters.

ProRail and DB Netz have determined the following maximum train lengths (including traction vehicles) for freight trains at the border crossings:

Border Crossing	Max Train Length (Meters)
Oldenzaal – Bad Bentheim	**590**
Zevenaar – Emmerich	**690**
Zevenaar – Emmerich	**650**

Table 49: Maximum Train Lengths in NL by Border Crossing

Source: NL Rail Network Statement 2019

In exploring alternatives and in discussion with various Delphi sources, a solution emerged, in that the longer trains allowed in Germany would instead terminate at Forst yard, located in the Cottbus area, which is at the German-Polish border crossing, near the Oder River. From there, trailers would be unloaded from the train and the remainder of the trip would be by road to destinations in Poland.

Additionally, with respect to costs associated with the paths at the border crossings of Belgium and Netherlands into Germany, many details of the actual interchange at the borders were unknown and could only be estimated. The costing parameters were based on known infrastructure path and energy costs per kilometer, as published in the infrastructure managers' network statements.

These cases were examined in comparison to an all-rail mode selection and the results are below.

5.6.5.1 Case 5 – Rotterdam – Forst (Wroclaw)

This case is troubled and incurs only losses. Cost areas are due to only shorter trains allowed in (see the above table for train length restrictions at border crossings between The Netherlands and Germany), generally high labor costs and the seeming inability to use an electric locomotive along the routing assigned by DB Netz, rather, only being allowed a diesel locomotive from Forst.

Theoretically, according to the traffic data, the traffic count is higher to and from Wroclaw, rather than from Posnan, yet this case seems to incur high losses.

According to the cost model, this case suffers a first-year loss of -€697.040 and the second- and third-year's losses move progressively to -€870.551 and €921.990, respectively. Over a three-year period, Case 5 losses are a cumulative -€2.489.581.

5.6.5.2 Case 6 – Antwerp – Forst (Wroclaw)

This case suffers even heavier losses than Case 5. The cost areas are the same as mentioned above in Case 5, but the infrastructure costs to the Port of Antwerp (Combinant) are very high, partially due to the circuitous characteristics of the infrastructure path(s) and the very high energy cost incurred by the necessity to use a diesel vs. electric locomotive for these routes. The problem is in the routing from Germany and through Belgium. Either the line to/from the port is electrified, but follows a meandering, circuitous path, with relatively low energy costs, but higher transit times, resulting in high labor costs, as well as the higher cost of the longer path itself.

The first year of operations for this case resulted in a loss of €1.172.590, with subsequent year 2 and year 3 losses of -€1.360.367 and -€1.420.154, respectively.

Cumulatively, Case 6 loses €3.953.112 over the three-year span modeled and is the last choice of the eight cases modeled.

5.6.5.3 Case 7 – Antwerp – Forst (Posnan)

Case 7 financially performs much better the cases 5 and 6. Though similar known (and unknown), cost elements still apply, the combination of variables point to a profitable operational case.

The first year of operation achieves a profit of €548.590. The second and third years achieve better results, at €605.910 and €567.091 respectively, in profit.

Cumulatively, Case 7 over three years, generates €1.721.592 in profits, making this among the first choices to select, amongst the field of eight cases.

5.6.5.4 Case 8 – Rotterdam – Forst (Posnan)

Case 8 performs better than Case 7. The model shows the first year's profits are estimated at €738.425. The second year's profits are €801.440 and the third year's profits are €766.897, the best financial performance of all eight cases.

The cumulative profits over a three-year span are €2.306.762, far better than any of the other seven cases. The costing model clearly shows that Case 8 is the most optimum case choice.

5.7 Summary and Initial Conclusions of Cost Simulation Model

To summarize in succinct paragraphs, the purpose of Chapter 5 is, based on a disaggregated data set, comprised of the volume of qualifying cargo types and qualifying segment lengths in kilometers (>=500 km), to select prospective O/D pairs and identify a base of concrete traffic flows for further analysis. The route characteristics of O/D pairs selected would have costs associated with operations, which would be calculated by applying a cost simulation spreadsheet model.

The concrete flow data itself was in the form of base tonnages between O/D pairs, but without distinguishing between the target commodity cargo categories. This required a step to further reduce the gross tonnage values into tonnage sets of qualifying commodities, namely those commodities that have a high probability of being transported in unitized loading units, such as containers and trailers.

The heaviest concentrations of those qualifying commodity tonnages over routes between O/D pairs that also linked ports at least the origin or destination, larger population centers, signifying consumption, as well as production areas (economic clusters), along with longer distances (>500 km) and good traffic balance in both directions then became the criteria for research (route) candidates. The characteristics and unique attributes of the route segments linking the O/D pairs generated total cost and revenue data, based on selected criteria, such as number of wagons in a train, number of trains, load factor of the trains and rates per kilometer generated tables that became the data set available for analysis.

Next, realistic estimates of fixed and especially variable costs on a granular basis became the basis for calculating total costs. Within the model, there is flexibility integrated into the design, in that any of the variables can be amended with updated information, such as a change in path costs, energy (kWh) costs, equipment lease costs, personnel costs or any other variable and even fixed costs.

As regards revenue, number of wagons, given allowable train length per route(s) and segments, translating to number loading units possible, revenue per loading unit and load factors (both directions), variables that are all researcher-selectable, as well as loading on the return trip cycle, comprised realistic revenue projections.

The combined values are the basis for calculating costs and conducting profitability analysis to arrive at breakeven, profits (or losses), for a given load factor scenario, number of wagons and train frequencies over routes linking selected O/D pairs and ultimately answering the research question.

If the RU enterprise can be shown to be profitable under any of the O/D pairs and routes depicted, represented as case scenarios, then the analysis will answer the research question in the affirmative.

Predicated on the OD pairs analyzed, the data shows that the O/D pairs of **Antwerp – Wroclaw** and **Rotterdam – Wroclaw** appear to offer the firmest base of the type of traffic that would best enable an RU to convert truck traffic to container or combined transport (CT) volume. One of the main objectives is to have enough volume of the type of commodities, in both directions, that could be containerized or put into trucks for transport by rail in either direction.

Both origin and destinations pairs offer that potential.

The conclusions are based on real data and are preliminary, in the sense that with updated traffic and cost data, new analyses can be conducted, as the fundamental analytical structure is now in place to repeat the analyses as often or between any O/D pairs, if the data inputs are available.

Chapter 6 – Financial and Risk Analysis will cover the analyses of the operational scenarios or "cases" in greater detail.

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[i] In discussions with a leasing company for representative rolling stock costs and an RU in Poland, I suggested the routes covered in Cases 1 – 4. They provided advice about the train length limitation of 600 meters and alternate strategies. That resulted in the amendment to the cases, in the form of using trucks for the first and last segments of the trip cycle. The difference in trailers allowed in a train in Poland vs, DE or even NL and BE would theoretically make the difference between profit and loss. Hence, the modification using the additional sub-cases.

CHAPTER 6 – FINANCIAL AND RISK ANALYSIS

6.0 Introduction

After analysis of the traffic data from the previous chapter, ***"Empirical Application of the Cost Model"***, it was now possible to draw the tonnages, distances, categories of commodities transported, modes, transit times between points throughout Europe. Filtering data by the criteria of >500 km, NST/R code commodities most likely to be transported in trucks or containers, between population, production, consumption centers, ports and terminals or any qualifying combination, based on criteria established in Chapter 4, gave an approximate indication of those qualifying tonnages between O/D pairs. From those filters, O/D pair selections were made.

With some indicative tonnages of traffic flow between selected O/D pairs as a basis for revenue projections, a cost model could now be developed to use the data. The model takes the form of a cost simulation spreadsheet that includes the most fundamental category elements of an RU's financial structure, such as revenue, fixed and variable costs.

Because the focus is on commodities likely to be transported in containers or truck trailers as the loading units to be transported, pricing of bulk, chemical, timber, grains, ores, etc. will not be addressed, though through the underlying design, there will be a provision built into the cost simulation spreadsheet for this feature in later iterations and for further research.

6.0.1 Revenue Assumptions

Based on Delphi sources[58], for commodities likely to be transported in containers or trucks, a general revenue figure of €1.10 per km will be the basis of overall charge for truck loads and €.90 per km for rail loads of similar commodities. As these are blended figures, there is no breakdown of specific commodities within loading units. The €/km rates by rail and truck were further validated by historical rates, as reported in the ***"European Road Freight Rate Development Benchmark Report – Q1-2020"***, published by **T*i*-Upply**, a British research firm on quarterly basis and detailed further in **Section 6.3.1**, as well as in **Appendix F**.

As another cross-check, to set an approximate rate basis for 40 ft. containers transported in the same general region (since the largest trip segments are in Germany in the model case scenarios), a cross-section of rates, according to research by the cited publications in this

[58] Per Chapter 4, page 13, paragraph 6, "Lastly, as a reality check, one would implement the "Delphi" method and speak with ports, rail operators, freight forwarders, terminal operators and integrated companies and, if possible, get empirical data. This could be problematic, as much of their internally generated data is proprietary, however, some form of discussion with them would be helpful to gain perspective, however incremental that might be."

paragraph, the rate for transporting a 40 ft. container within Germany by truck was €1.14/km. Black et al. (2003). The rate for moving a 40 ft. container from Hamburg to Bavaria by truck was €1.14/km. A 40 ft. container moved in intermodal transport averaged €.89/km, while rail-only for the same loading unit between Hamburg and Munich was €.79/k, per HHM (2012).

Between the three sources cited, a researcher could reasonably establish a bracketed rate range between €.70 - €1.20/km for case scenario simulations.

6.0.2 Fixed Costs

The fixed costs are based on this author's observations of general estimated costs of smaller enterprises in base administrative and equipment categories and are, in general, not unique to RU's. This category of costs is commonly known as "*sales, general and administrative*" (SG&A).

6.0.3 Variable Costs – General

Many of the other variable costs are unique to a typical RU and include path costs, energy (diesel or electric), labor, locomotive changes at borders, as needed, shunting, loading unit transfers at terminals, terminal costs, as well as pre and post handling (PPH), (as applicable), all of which vary by volume.

6.0.4 Variable Costs – Rolling Stock

The category of rolling stock, in which a certain mix of locomotives and wagons are needed for base service levels, along with their insurance and running repair expenses, such as brake blocks, air hoses, rubber gaskets, lubrication, filters and similar light maintenance items.

As mentioned previously, normally, lease costs are treated as fixed costs because, regardless of the utilization level of the equipment, the base roster of equipment must be on hand to conduct business. In this simulation, however, all equipment is to be leased with maintenance included and will not be owned by the RU, thus no depreciation costs.

Nevertheless, in the cases modeled, lease costs and associated insurance and maintenance costs will be considered variable costs, because it is possible to lease on a relatively short-term basis, "spot leasing", to accommodate customers who may want to test their experience with rail transport, before committing to a long-term transport agreement.[59]

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[59] An RU would not want to risk a long-term lease that is not tied to a matching term transport contract that would cover the RU, in case the customer decided that rail was not the right choice. The conundrum is that customers also do not want to risk a long-term contract on a service that may not be satisfactory. For that situation, a common practice is to lease the equipment on a short-term basis, work out the operational irregularities that inevitably emerge and then, when everything is operating smoothly, then execute an agreement, based on the now-known factors.

6.0.5 Variable Costs – Path Costs

Path costs were difficult to calculate, despite formulas in each infrastructure manager's respective network statements, as certain lines were out of operation, had axle weight restrictions, train length limitations, and/or did not have electrification. For operational reasons, certain path combinations were not available for paths that were direct and straightforward. This resulted in many paths over meandering routes, incurring greater cost due to the length of trip, cost per km, train length restrictions and/or axle weight limitations.

Additionally, **RailNetEurope (RNE)**, the clearing house for rail network paths, based in Austria, has an online path pricing tool known as the **CIS (Charging Information System)**[60], that will not properly calculate infrastructure path pricing across borders. It will calculate approximate costs within one country (though not energy costs), between origins and destinations, but often requiring many waypoints along the route to be entered. There is no provision for any locomotive changes, associated shunting or demonstrated restrictions of train length, axle weight, etc. in the calculations, rendering them approximate, at best.

DB Netz has a very thorough pricing tool for path costs within Germany, but not beyond its borders. Nevertheless, it has proven a useful tool and the basis for some energy costs, with respect to kilowatt hours consumed by different types of locomotives. Those calculations have been useful in applying consumption rates * route kilometers for certain types of locomotives, such as Class 66 diesel-electric locomotives and the BR 185/186/189 class locomotives, as well as a large table of other locomotives, which have been homologated and in operation throughout Europe.

6.0.6 Variable Costs – Applied to Simulation Model

Due to these limitations, the variable costs calculated are approximate and subject to further refinement as more precise data becomes available at the time when an updated quote is needed for the start of service. The model will accommodate changes in the cost basis of selected categories, by changing data in the underlying reference tables. However, for the purposes of general cost indications and determining the broad cost values to insert into the simulation model for any two O/D pairs, this tool should be sufficient to give a general overview of costs, profitability and a perspective, as to what operational cases are realistic. The data results generated from the model can then be later used as inputs for sensitivity analyses.[61]

[60] This tool is intended for use for all of Europe, but the organization is based in Austria.

[61] After the cost simulation is run, there are certain rates, load factors, numbers of wagons and other criteria that will give a range of rates per km to use in a sensitivity analysis, comparing with truck. If one has a good sense of what the revenue and cost structure is, then it will become known, as to whether the rail revenue values are

The model takes the approach of case scenarios, representing certain path and rolling stock combinations, subject to territory limitations.

6.1 General Overview

Eight cases were modeled using four O/D pairs, with two basic operational scenarios. The objective of the analysis is to determine in which cases optimum profitability can be achieved.

The case scenarios modeled are:

1. Rotterdam – Wroclaw, using rail mode only
2. Antwerp – Wroclaw, using rail mode only
3. Rotterdam – Posnan, using rail mode only
4. Antwerp – Posnan, using rail mode only
5. Rotterdam – Forst - Wroclaw, using both rail and truck modes
6. Antwerp – Forst - Wroclaw, using rail and truck modes
7. Antwerp - Forst – Posnan, using rail and truck modes
8. Rotterdam- Forst – Posnan, using rail and truck modes

There are two types of analyses performed.

6.1.1 Overview - Investment Analysis

The first analysis is in the form of conventional business metrics to determine the overall profitability of an enterprise over a three-year timeline from an investment perspective and identify case scenarios of maximum profit over time.

- Net present value (NPV)
- Internal rate of return (IRR)

Both metrics need the following inputs:

1. Total cash inflows and outflows
2. Timeline
3. Discount or capitalization rate

Determining the overall profitability of the cases starts with the initial investment into an RU enterprise. In the analysis, a first step is setting the discount rate, which establishes the

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realistic to be competitive with truck. The cost simulation model is the tool to help determine a range of input values.

threshold return for investors, after which NPV and IRR are calculated from the revenue, total costs and profits derived from the simulation spreadsheet over a three-year timeline.

6.1.2 Overview – Sensitivity Analysis of Two Cost Variables

The second analysis goes beyond the objective of identifying case scenarios of maximum profit over time and offers deeper insight into the factors that determine profitability. This is a sensitivity analysis.

The objective of both analyses to gain insight into how to maximize profitability and therefore, determine which of the scenarios offer the greatest return and in the case of the sensitivity analysis, determining the how two higher costs variables affect NPV and IRR, and ultimately, the dependent variable, profit.

The two independent cost variables examined and their range of values are:

- Energy costs, 75 - 250% of baseline costs, in increments of 25%, after 60.75% initially
- Path costs, in increments of 2%, 50%, 100% and 150% of baseline costs

The details of applying the sensitivity analysis will be explained further and in detail within **6.8 Sensitivity Analysis of Two Cost Variables – Step 10** and detailed analysis results of each case can be found in within the section and at the end of the section, where the tables of the entire range of values of each cost variable for all eight cases can be found.

6.2 Analysis – Investment, Foundational Elements

Determining the overall profitability of the cases starts with developing realistic baseline assumptions to evaluate the case scenarios. The baseline assumptions are used to construct the initial cost structure, needed to calculate the initial investment required to fund the RU enterprise safely, until sufficient and consistent revenue begins to flow.

Once the cost assumptions are in place and the amount of the initial investment is determined, the next step is setting the nominal discount rate, which establishes the threshold return level required to generate investor interest.

When the cost assumptions are known, the initial investment is determined and the discount rate is established, the foundational elements are in place and the analysis can proceed. The analysis will use scenario Case 1 to use in developing a template for generating calculations evaluating the investment for this case.

6.2.1 The Structure of the Investment Analysis

Step 1
Establish assumptions

Timeline to measure the investment

Step 2
Determine the initial capital investment needed per case

Step 3
Set the discount rate, which establishes the threshold investment return necessary to generate investor interest

Step 4
Assess growth rate

Step 5
Identify and assess risks

Step 6
Evaluate case scenarios

NPV
IRR
Terminal Value

Step 7
Sensitivity analysis

Step 8
Recalibrate after more information is known

More risks are researched and become known
Revisit market rates for service

Step 9
Implementing the use of the cost simulation spreadsheet tool to confirm or reestablish new parameter combinations for further analysis

6.2.2 Assumptions for Analysis - Step 1

6.2.2.1 Timeline

An important initial document is the proforma income statement, needed to estimate the annual cash flow. While five to ten years is a normal timeline for investment, for this research, three years have been projected, because, aside from overall profitability, the approach is also to minimize investment risk, as detailed within **Section 6.2.4.2 – Internal Rate of Return (IRR)** in calculating the discount rate.

Accurately assessing the stages that a company may be at in its development is important to applying realistic projections to a company. The company could be considered an early, but high growth stage, or it could be medium or mature stage, with a stable growth or even a perpetual growth rate company. While, in general, smaller firms grow disproportionately faster than their more mature counterparts, in this case, because the rail logistics sector is mature and quite conservative (and capital intensive, especially if equipment is purchased), it is appropriate to consider this prospective RU as an early-stage enterprise with a stable, but not spectacular growth rate and certainly with no guarantee of perpetual growth.

Due to these factors, to be conservative and minimize risk, a timeline of three years will give investors a rather good indication of how an RU enterprise will trend financially. Since the equipment is all leased, there is no depreciation, nor amortization for heavy maintenance required. Terminal values, therefore, will be tied to the final accumulated revenue accrued over the three-year timeline. [62]

6.2.2.2 Assumptions Summary

The following are the assumptions or inputs to consider for Case 1, as a representative example and explained in further detail in Chapter 5:

1. The initial capital cost of €3,300,861.52 for commencement of operations represents the cost of six months of operations, including a 5% contingency.

2. The time periods examined will be for three years, based on initial short-term equipment "spot" leasing, possibly transitioning into long term leasing, later, as the cases prove themselves to be commercially viable. Spot leasing will be used to minimize risk for the RU, due to the difficulty in getting customers to commit to longer terms of

[62] Dablanc, Laeticia, ***"Quel Fret Ferroviare Local? Réalités françaises, éclairages allemands"***, (2008) P.202 & 215, timeline matches with European funding mechanisms under Regulation No. 1998/2006 for "De Minimus Aid" and "*These funds can be allocated for three years*" and under the "Marco Polo Program", Regulation 1692/2006, one of the main conditions of funds allocated under this program is *"…the project must achieve its objectives in 36 months, thanks to a realistic development plan."*

rail use, in turn and due to rail's preceding reputation as a lower quality option, both in terms of reliability and transit time. (This perception can only be reversed through an established history of positive performance demonstrations).

3. There is no lifespan calculation of rolling stock (equipment) because it is leased.

4. The payback period is three years with a nominal discount rate of **18.031%**, due to the high risk.

5. Residual value is not calculated here, because the equipment is leased. However, a terminal value figure will be substituted, based on the aggregate retained earnings at the end of the 3-year period of operations.

6. The assumed load factor will be conservatively estimated at 80%, but the equipment (number of wagons) leased will be assumed to be at the longest train that can be accommodated on the national systems the operation will traverse, plus reserves. The maximum length of train allowed will accommodate 17 Type T-3000 "pocket wagons", but the total leased wagons will be 17 wagons x 2 trains, plus 3 wagons allocated to each train for maintenance reserve and cycling x2 trains, totaling 40 wagons.

Figure 13: T-3000 Pocket Wagon

Source: Roco Model Trains

7. The tonnage of the train will be fixed at the combined weight of the wagons and their maximum load capacity, plus the weight of the locomotive.

8. For the base case, the annual trips are based on the average of one round trip ***per trainset*** per week x 11 months = 48 weeks, plus only two weeks of operations in December, due to the Christmas and New Year holiday, for a total of 50 weeks. The number of trainsets will be two, based on the need to provide a minimum frequency of two departures per week in each direction, to be attractive to both shippers and logistics providers, the market for the rail service. (Later, an increased number of trainsets operated can be modeled, as the simulation spreadsheet model can accommodate this).

6.2.2.3 Initial Investment – Step 2

Based on the income statement from Case 1, an initial investment can be calculated. The method for determining the investment for this case is to have all the administrative systems, rolling stock, personnel, insurance premiums and regulatory obligations in place, prior to startup.

An investor would look at the monthly "burn rate" of the above expenses and conservatively assume that for six months, no revenue will be flowing in. While that may not be strictly true in many cases, long experience has shown that it is better to have the funds reserve to withstand the absolute worst-case scenario, no revenue, until business is built up to a point of positive cash flow, as most business development requires substantial gestation time. This general business principle is established as a prudent approach, as undercapitalized businesses have a poor survival rate.

Based upon the projections, the needs for scenario Case 1 are estimated to be approximately €3,300,861.52, considering the aggregate of all fixed and variable expenses for six months of operations.

Therefore, €3,300,861.52 would be the base initial investment figure to apply to formulas. The initial investment for each of the cases may differ slightly, but they are calculated similarly.

6.2.2.4 Deriving the Discount Rate – Step 3

To achieve more complete granularity to the method, the nominal discount rate applied to the cases is based on factors described further in **Sections 6.2.2.5 – 6.2.2.9**, as the risk-free asset rate, equity risk premium rate, company size premium rate and sector risk premium rate. The summation of these factors will equal the discount rate. Note that the nominal vs. the real discount rate[63] is applied to this research for simplicity, as inflation is a moving target and difficult to apply abstractly.

6.2.2.5 – Risk-free Asset Rate

A risk-free asset rate, which could be a stable, sovereign bond, such as a 10-year Belgian Government Bond yield, currently at .031%, but recently range between -.015% and .066%. Other qualifying assets are the US Treasury 10 Year bond, currently at 1.4% or the German Federal Bond Rate at -0.4535. Few rational investors would place their funds in a bond yielding negative interest and though the US Treasury Bond yields higher rates, since the venue of operation is Europe, the Belgian bond is the choice.

6.2.2.6 – Equity Risk Premium Rate

This rate is known as the “opportunity cost”, often called an equity risk premium, for a substitute investment in the stock market. A conservative return of 5% is realistic. (Mercer Capital, 2021) [64] (CFA Institute, 2022) [65]

6.2.2.7 – Size Premium Rate

Smaller sized companies are inherently riskier and command a size premium. The general figure to apply is 6%. (Mercer Capital, 2021) [66]

6.2.2.8 – Sector Risk Premium Rate

There are numerous risks of varying magnitude, mostly exogenous for this sector. **Section 6.2.3 Risks and Uncertainty** outlines many of the risks in greater detail, with examples. For this specific type of industry sector risk premium and depending on the stability of the sector, it could range from 5% – 9%, let’s say, in this instance, 7%. (Mercer Capital, 2021) [67]

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[63] Real Interest Rate = Nominal Interest Rate - Inflation Rate

[64] To capture generic market risk for the equity market, appraisers employ an “equity risk premium,” frequently in the range of 4.0% to 7.0%, which captures what an investor would expect for an investment in the equity market over a less risky investment like the bond market. (Source: Mercer Capital, (2021))

[65] In a forum with investment professionals, Laurence B. Siegel, Roger G. Ibbotson, Martin Leibowitz, Jeremy Siegal and numerous others, the general consensus was 5% - 7% equity premium.

[66] Smaller companies tend to be subject to greater issues with concentration and diversification. Smaller companies also tend to have less access to capital, which tends to raise the cost of capital. To compensate for the higher level of risks as compared to the broad larger equity market, appraisers frequently add a premium of approximately 3.0% to 5.0% (or more, for very small businesses), to the discount rate when valuing smaller companies. (Source: Mercer Capital)

[67] Mercer Capital regularly reviews a spectrum of studies on the equity risk premium and also conducts its own study. Most of these studies suggest that the appropriate large capitalization equity risk premium lies in the range of 4.0% to 7.0%.

6.2.2.9 Weighted Average Cost of Capital (WACC)

In overview, a company's capital structure will have two components, debt and equity. The E/V part of the formula represents equity-based capital, while the D/V portion is the debt or finance-based capital. Though each category of capital will also have subcomponents, in aggregate, the two categories are proportionately weighted.

WACC Formula = (E/V * Ce) + (D/V) * Cd * (1 – Tax rate)

Where:
E = Market Value of Equity
V = Total market value of equity & debt
Ce = Cost of Equity
D = Market Value of Debt
Cd = Cost of Debt
Tax Rate = Corporate Tax Rate

For the purposes of this research, a more simplified version of WACC will be implemented. In the formula above, there are factors that will not be appropriate for this analysis.

1. The market value of the equity, **E**, in the form of share price * issued shares in the marketplace will not exist in that form, because no public shares would have been issued. Instead, paid-in capital will be used.

2. In the case of **D**, this type of enterprise will not have debt in the form of senior (long-term) or subordinated (shorter-term) debt.

3. For **Ce**, the cost of equity, the Beta factor, an expression of volatility of share price will not be used, because a startup RU is unlikely to have issued stock in the public markets, so Beta is not applicable.

The amended version of this formula that is more appropriate in the case is:
(E/V) + (D/V) * Ce * (1-tax rate)

Equation 2: Amended Weighted Average Cost of Capital (AWACC)

6.2.2.10 Cost of Debt

In this research, the RU cases will not have debt, but should that be necessary, the simulation spreadsheet model can accommodate this factor.

6.2.2.11 Cost of Equity

The cost of equity stems from the expectations of investors, as to a return on their investment. Investors will view the investment from the various perspectives, some motivated by pure financial incentives, some investors have larger, strategic objectives, such as consolidation, "bolt-on" operations added to other complementary enterprises and yet other investors may have in mind to grow the business quickly and "flip it", to achieve double-digit returns. Still, other investors may simply find the rail sector attractive and are motivated by wanting to re-engage in the industry, after having been bought out from a similar enterprise, retirement or even for personal status reasons of being involved with the "glamour" of the rail industry. Regardless, investors expect a return on investment, the most common (amongst all primary or secondary) motivations, is a blend of financial and/or strategic. Defined more simply, the cost of equity is the investor's expected rate of return, compared to alternative investments.

6.2.2.12 Growth of Companies – Methodologies – Step 4

There are two basic ways to evaluate a company's growth.

- Top-line or revenue growth
- Internal growth rate

6.2.2.13 Top Line Revenue Growth

For this type of evaluation, analysts consider the growth rate of the company, the industry sector and the growth of GDP or the general economy. For top-line growth, analysts consider first the GDP growth of the economy, the growth of the industry sector the company belongs to and then finally, the company itself. In this analysis, according to industry sector risk premiums established by multiple commercial data services. For a compilation of industries, the Stern School of Business of New York University aggregates this data from multiple data services for researchers. Source: https://www.stern.nyu.edu/~adamodar/New_Home_Page/data.html. The railway transport sector is estimated to be approximately 7% and is a component of the discount rate.

6.2.2.14 Internal Growth Rate

In this method, the return on equity and growth in retained earnings are most important and this represents bottom-line growth. The second consideration in this method is also the "top to bottom" growth rate, as well as the internal growth rate, the combination of which can help predict future revenue. The internal growth rate is most appropriate for this research, as manifested by revenue growth. Revenue growth is fixed at 3% per year (but, easily adjusted with new information), and in the simulation spreadsheet, is tied to this adjustable value in a reference table tab. Revenue growth is conservatively linked to estimated inflation, due to the market vagaries, with respect to increased market share, traffic volume and risks, discussed in **Section 6.2.3 Risks and Uncertainty.**

6.2.3 Risks and Uncertainty – Step 5

Risks and uncertainty are considered differently, depending on who is evaluating the risk. In the public sector, risks that have the possibility of being assessed through quantitative probability calculations are considered non-systemic. Those risks that have uncertainties and are difficult to quantify are called systemic, with qualitative analysis being more appropriate. There are two expressions of confidence categories, which are broadly defined as risks and uncertainties. According to Crozet (2014), it is useful to construct a typology of risks organized by their characteristics, as to whether they are internalized in economic calculations or evaluated qualitatively.

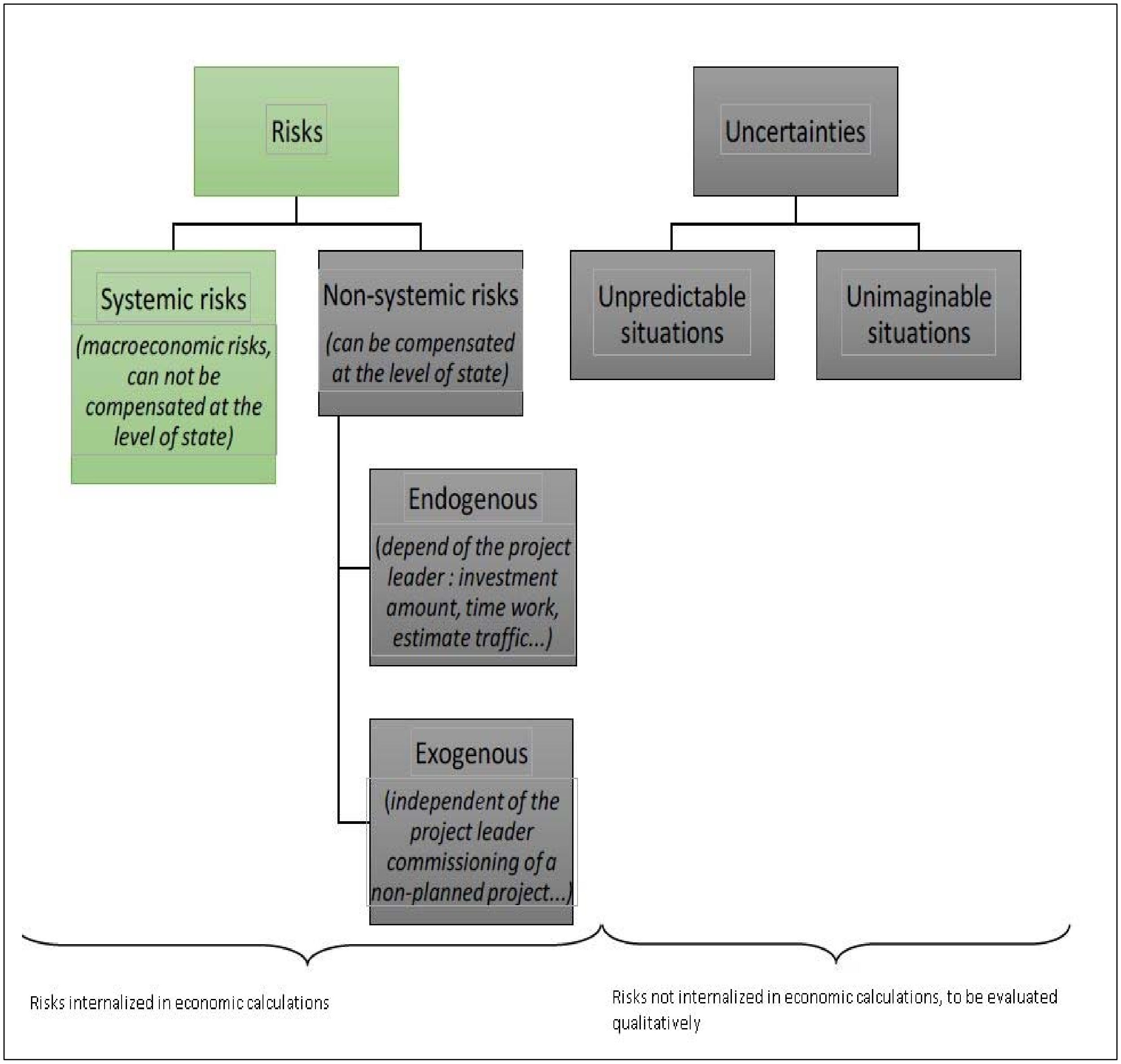

Figure 14: Typology of Risks

Source: Crozet (2014)

6.2.3.1 Risks

Some basic points about risks and uncertainty are defined, with their respective categories. Risks (adverse events) and their potential for occurring are quantified through probabilities. Within the classification of quantifiable risk are two sub-categories:

- **Systematic**
- **Non-systematic**

Systematic risk can be considered macroeconomic in nature and not applicable to this research. Non-systematic risk can be further subdivided into endogenous and exogenous risk.

6.2.3.2 Endogenous Risk

Endogenous risks are related to factors related to the proponents and/or people involved in the management and conducting the operations of an enterprise. Examples are those who have some input, control of and /or can affect factors, such as traffic volume, costs and revenue estimates, setting investment horizons and level of capital investments (or funding).

6.2.3.3 Exogenous Risk

Exogenous risk is not related to the managers of the enterprise, rather, the risk factors are more related to the underlying data upon which the investment thesis is based. If the data is unreliable and/or sparse, a remedy to this is to conduct a sensitivity analysis. Selecting variables that are relevant to the sensitivity analysis is fundamental. Those variables also fall into two subcategories:

- Variables which the enterprise’s management can strongly influence
- Variables which the enterprise’s management cannot strongly or not influence at all

As the risks relate to the rail sector, Figure 15 illustrates the categories and their relationships to each other.

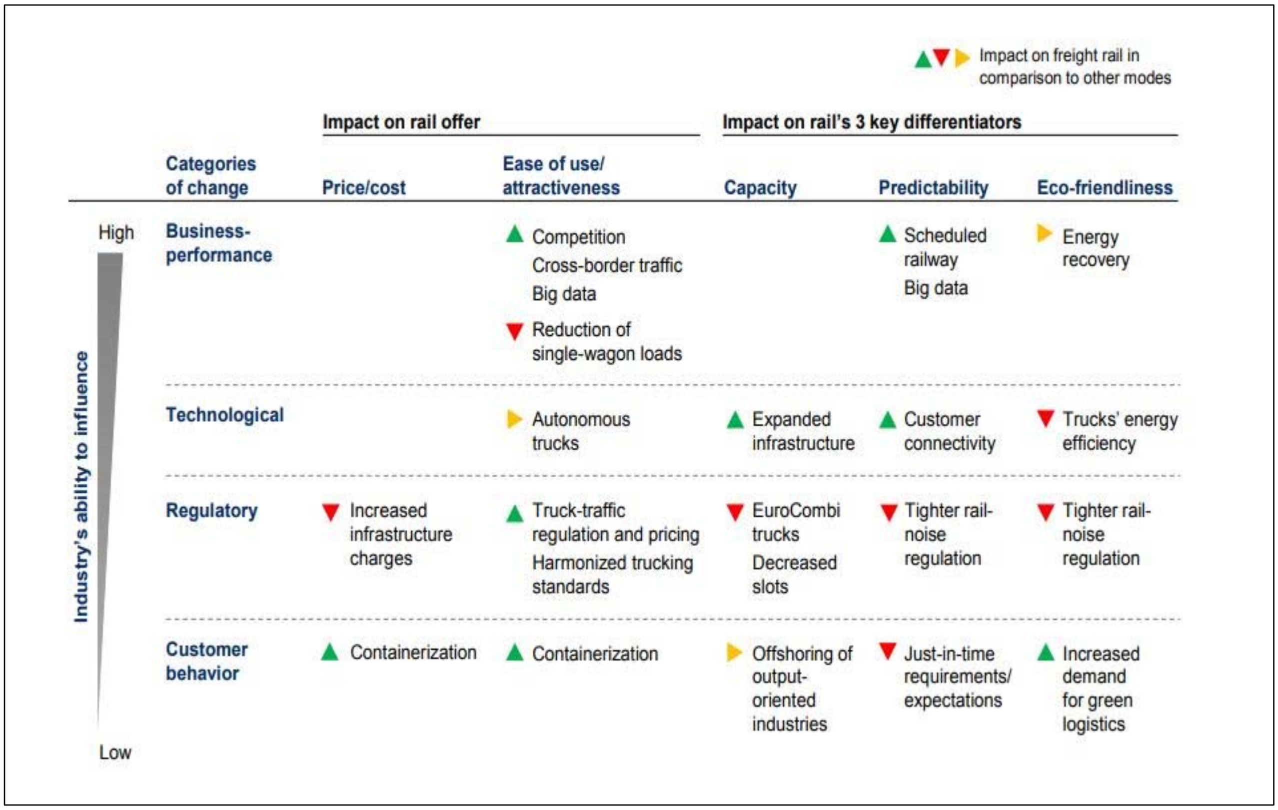

Figure 15: Development of Rail Future Modal Share Subject to Several Forces

Source: *"Getting Freight Back on Track"*, **McKinsey (2014)**

There are exogenous risks that are difficult to quantify, but are realistic and have manifested.

The following are types of those exogneous risks:

1. **Safety Risk.**
   The recent banning of "pocket wagons" on the Danish national railway system, due to an accident on 13 January 2021, involving a container that was not properly fastened, resulted in the loading unit colliding with the front of a passenger train traveling on an adjacent track in the opposite direction. This accident resulted in fatalities and the infrastructure authorities, in their caution, banned all such wagons on the Danish railway network. "*This has resulted in massive losses for RUs operating intermodal trains, estimated at over €1 mm per week. The financial impacts cascade down to, not only the RUs, but the logistics companies, the leasing companies who are the owners of the wagons, the terminals at both ends of the trip cycle, as well as the broad*

environmental and social impacts by using trucks as a substitute mode." Source: Railfreight.com (13 April 2021)

2. Regulatory Risk

2a.

In Germany, there was a new legislative proposal to be reviewed by transport commission of the Bundestag on 14 April 13, 2021, in the context of increasing rail modal share from 18% to 25%. The matter at hand was the proposal for DB Netz, Germany's infrastructure authorities to open the railway network up to more competition. A long-standing issue is that DB Netz favors publicly owned RUs, in which the government of Germany is the sole shareholder in DB Netz, as well as DB Cargo, DB Fernverkehr and DB Regio. Because of this built-in bias as both the shareholder and the regulator, privately owned RUs are not given fair priority access to the network, to their detriment, because it makes those RUs less competitive, relative to DB Cargo. Further, the German Court of Auditors does not agree with the private RUs' argument, leaving them with little recourse to their disadvantageous position. This constitutes a substantial risk to the commercial viability of the private RU sector. In effect, RUs operating in Germany are in competition with the German government for cargo. Source: Railfreight.com (13 April 2021)

2b.

Infrastructure managers can impose restrictions on maximum train length that heavily influence profitability. Just the addition or subtraction of 30 to 40 meters of train length can mean the difference between profit and loss of a train and indeed, of a scheduled operation. An example of that is imposing a train length limit of 600 meters over the Polish railway system that results in a short and unprofitable train. It is for that reason that scenario cases 5 – 8 exist, as the last short segment from Germany into Poland transfers to truck in Germany at the Polish border. Regulatory directives to reduce efficiency through shorter train lengths represent substantial financial risk.

3. Regulatory and Technological Risk

3a.

The EU is implementing a new ERTMS signaling system over the European network with the goal of interoperability over the entire European railway network. While the goals are laudable, the cost for public operators, estimated at approximately €500k per locomotive, will be completely paid for by the respective railway systems, which are publicly funded. However, the private RU operators must bear this cost themselves, which often exceeds the value of the older locomotives the systems will be installed upon. The prospect of increased regulation and compliance costs represents a substantial risk.

3b.

The effects of insufficient terminal capacity to handle traffic expeditiously, so that quick turnaround times are possible. The risk is that train cycles could be adversely affected, which would then diminish the marketability of the degraded service levels, utilization of rolling stock and efficient deployment of operating crews.

3c.

The effects of insufficient terminal capacity to handle sufficient train length and hence, the number of wagons in a train. The risk is that the number of wagons in a train allowed are insufficient for revenues to exceed costs and for the RU to achieve scale. This is currently very much the case in Duisburg, Rotterdam and other terminals today.

3d.

The effects of network infrastructure not electrified, forcing the use of diesel locomotives, circuitous routings, decreasing overall train velocity, increasing path kilometer and personnel costs, all of which negatively affect rail and diminish its ability to offer competitive services, in comparison to trucks.

4. Market Risk

The ever-shrinking market for wagon-load traffic is an impediment to both increase in modal share and the marketability of the rail mode offering. The ability of freight customers to receive cargo by carload enhances the rail service proposition. From **Section 3.4.2.6**, in response to network "rationalization" initiatives, local RUs *"…have been organized to either preserve railway service in a line abandonment program, such as that implemented by DB under the "Mora-C" program, whose intent was to "rationalize" unprofitable branches. Faced with losing service, entrepreneurs stepped in and organized enterprises to operate the heretofore unprofitable lines, however regarded as necessary to preserve economic links for their local communities. In other instances, they have re-established service over formerly abandoned lines, but with* *capital raised locally, repairs and renovations were made to the infrastructure to allow the line to return to service. Often, one of the driving forces behind these local RU enterprises are industries that need the rail service but cannot attract a former incumbent railway's attention and are in danger of becoming captive to more expensive motor carrier transport."* Endogenous and exogenous, in terms of business performance category.

5. **Technological Risk**

   The development of autonomous and/or electric trucks is a factor. While there may well be positive winds in favor of rail through legislative action against trucks for environmental reasons, it's also possible that truck operators will receive favorable tax and legislative perks for positive environmental effects of electric vehicles. And, autonomous trucks, seemingly far away, may gain market share through segregated infrastructure developed just for autonomous and electric trucks, lowering operating costs for road haulers and increasing their competitiveness against rail. *"The key principle of the Eurovignette Directive should be that zero- and low-emission trucks shall comply both with the user-pays principle (charging for infrastructure use) and with the polluter-pays principle (in this case the remaining non-CO2 external costs." "Reducing or even waiving tolls beyond accounting for lower CO2 emissions could further hamper rail's competitiveness versus road freight and lead to a reverse modal shift of up to 50 per cent in the 2030-2050 period – contradicting the objective of the EU Mobility Strategy of increasing rail freight traffic"*, Source: Joint statement of UIRR, CER and ERFA. Endogenous and exogenous with respect to market and technological changes.

6. **Equipment Risk**

   Equipment shortages are constant in the sector, both in loading units (containers) and the wagons to haul them. There are ongoing issues with equipment balance, complicated by various external events such as:

   - Shortage of containers brought about the Chinese policy of the export prohibition of China Railways' containers, requiring the marketplace to use its own containers.
   - Reduction in the frequency of service schedule from China Railways, resulting in less capacity and poor container cycle time, as well as raising prices.
   - Events such as the recent Suez Canal blockage by the Evergreen container ship "Ever Given" have constrained capacity, as shippers seek alternatives, which include rail.

- Not having sufficient loading units means that some customers cannot be accommodated, even if the route capacity exists. Source: RailFreight "*And up goes the container rate… again*" April 21, 2021

6.2.3.4 Risks and Uncertainty - Summary

As applied to an RU enterprise conducting transportation in any of the eight case scenarios, systemic and uncontrollable risk come partly in the form of the recent global pandemic, with effects of diminished commercial activity, adversely affecting logistic demand and volumes.

Offsetting general governmental policies favoring rail modal share increase, there are the realities of generally insufficient infrastructure to accommodate the increased rail volume. There are numerous reports of insufficient terminal capacity to quickly process wagons received inbound and to add wagons outbound for return trips, as well as yard tracks long enough to handle normal length trains, forcing trains to operate with fewer wagons. With high fixed costs, RUs are disadvantaged, because the analyses demonstrate that profitability is generally achieved only at the upper ranges of train length and load factor. Rates per kilometer are constrained by competition from other modes.

Regulatory and technological burdens imposed by governments constrain profitability and diminish the appeal of railways for investment, by increasing the capital costs for equipment to remain in compliance with regulations. A particular case in point is the upcoming requirement for privately owned RU locomotives to be retrofitted for ERTMS signaling equipment, but without reimbursement from the regulatory authorities, despite public RUs enjoying the reimbursement from their respective governments.

As mentioned earlier in this chapter, there is the challenge of privately-owned RUs competing with government-owned RUs for competitively timed network paths, for which the German government has ruled against private RUs in their case brought against Deutsche Bahn, with no recourse available to the privately-owned RUs.

Availability of sufficient rolling stock of the correct type and at lease costs that allow profitability are an ongoing issue. The incumbent RUs do not experience this problem, because they inherited rolling stock from their predecessor governmentally owned railway authorities, but the privately-owned RUs enjoy no such advantage, affecting their profitability and indeed, even their possibility of acquiring the traffic for their portfolios.

In addition, the current war between Russia and Ukraine has disrupted supply chains, especially as regards rail traffic from the Belt and Road Initiative (BRI), which has necessitated time consuming and costly rerouting, further diminishing rail's appeal, relative to maritime. The agricultural sector has also been affected, in that the logistics in grain and fertilizer movement have created shortages and have absorbed rail network and terminal capacity, by reroutes through NATO countries and terminal transloading between the wagons of Ukraine's 1520 mm and Europe's mostly 1435 mm gauge systems, as well as through Black Sea and Danube River ports in Bulgaria and Romania. This also influences wagon distribution throughout the EU network and creates imbalances.

Another effect of the Russian-Ukrainian war is on energy costs. Due to the curtailed use of Russian gas and oil, energy costs have rapidly increased, due to decreased supply through sanctions, not having backup energy sources in place (whether infrastructure for terminals to handle gas inbound or refinery capacity, worldwide), and a dependency on Russia for oil and gas. This has adversely affected all energy consumers, but, in particular, railways, whether the RUs use electric or diesel locomotives. Energy costs in fuel have also adversely affected maritime, truck and aviation.

The two above-mentioned uncertainties can arguably fall under systemic risks with their collective macroeconomic effects and are difficult to quantify. The other risks listed are similarly difficult to quantify.

With respect to energy and path costs for rail, there are measures that governments, in particular, the German government can take to ameliorate the destructive effect of high energy costs by curtailing or eliminating taxes on both energy and path costs.

In summary, the transport sector is fraught with risks, ranging from the uncontrollable, unpredictable and exogenous risks, systemic or synthetic, such as governmental policies that will raise costs through taxation and regulation. Other risks involve industry sector competition, rolling stock expense and availability, ability to secure competitive paths over railway networks, labor costs and especially energy costs. [68]

What remains is quantifying the overall risk, which will be addressed through item number four in calculating the discount rate, in which *"…the specific industry sector risk premium and depending on the stability of the sector, could range from 5% – 9%, estimated, in this instance, 7%."*

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[68] As regards electric power in Germany, in an article posted by the Associated Press on 12 July 2022, ***"German Official: Nuclear Would Do Little to Solve Gas Issue"***, Germany will shut down its remaining three nuclear power reactors in December 2022, further constraining power supply. According to the article, *"In the first quarter of 2022, nuclear energy accounted for 6% of Germany's electricity generation and natural gas for 13%."* This will have the effect of further increasing electric power costs, with effect on energy costs for electric locomotives.

6.2.4 Evaluate Investment – Step 6

6.2.4.1 Applying Net Present Value to the Cases

A measurement of the investment performance into the RU is to take the net present value (NPV) of the cash flow calculated over the measured term (3 full years) and compare each of the cases. It stands that the cases with the highest positive NPV are the cases to pursue for investment. The net present value (NPV) will then be applied to each case for comparison. Each cost component of the cases will be examined and the underlying assumptions explained, as will the basis for the revenues. The objective in this step is to determine the present value of free cash flow, plus the terminal value, as described above, to arrive at the present value. The present value of cash flows is calculated, which includes the weighted average cost of capital (WACC) value, comprising the discount rate applied.

In theory, there are two different NPV scenarios to consider.

1. **Net Present Value formula (when cash arrivals are even)**
2. **Net present value formula (when cash arrivals are uneven)**

For each of the cases, there are three years of cash flows to evaluate and there are no instances in which each year of cash flow is identical to the following or previous year.

If the cash flows were identical for each year, the NPV formula would be:

$$NPV_{t=1 \text{ to } T} = \sum X_t/(1 + R)^t - X_o$$

Where:

- X_t = total cash inflow for period t
- X_o = net initial investment expenditures
- R = discount rate, finally
- t = total time period count

However, if the cash flows were *not* identical for each year, the NPV formula would then be:

Equation 3: Net Present Value (NPV) when periodic cash flows are uneven

$$NPV = [C_{i1}/ (1+r)^1 + C_{i2}/(1+r)^2 + C_{i3}/(1+r)^3 + \ldots] - X_o$$

Where:

- R is the specified return rate per period.
- C_{i1} is the consolidated cash arrival at the end of the first period.
- C_{i2} is the consolidated cash arrival at the end of the second period.
- C_{i3} is the consolidated cash arrival at the end of the third period, etc.

Source: www.wallstreetmojo.com/net-present-value-npv-formula/

For example, the net cash flow from Case 1, years 1, 2 and 3 are, with this formula applied are:

Assumptions: 17 wagons with a load factor of 80% with the rate per km at €.90

Where:
Discount rate = 18.03%
Initial Investment: €3,300,861.52 (six months of expenses as initial capital)

Category	Cash Flow	Notes
Initial Investment	-€ 3,300,861.52	6 months estimated expenses
Fixed Costs	€ 243,275.00	Estimated fixed costs
Variable Costs	€ 2,893,735.97	Estimated variable costs
Contingency @ 5%	€ 156,850.55	Contingency amount of fixed + var costs.
Organizational	€ 7,000.00	Notary, attorney, etc.
Total	€ 3,300,861.52	**Initial Estimated Capitalization**

Table 50: Initial Capital Requirements – Case 1

The initial capital requirements needed to launch the RU venture are listed in **Table 47** and explained with the following assumptions.

1. The initial capital investment is based on six months of estimated fixed and variable expenses, given the base operation of two trainsets per week, with 17 wagons, with the train operating at 80% capacity and with prospective revenue of revenue at €.90 per km per loading unit, which could mean a 40 ft. container or 40 ft. truck trailer.
2. Though it is realistic that there would be some revenue flowing in, there are some very conservative assumptions that there would not be any income taken in the first six months of operations, for the purpose of having a financial buffer, should startup of traffic volume be slower than expected of a ramp-up to expected capacity estimates of 80%.

[(€1,808,345.39)/(1 + 0.01803)] + [(€1,892,473.95)/(1 + .01803)^2] + [(€1,878,952.28)/(1 + .1803)^3] = €732,416.13 = the net present value of 3 years of an uneven income stream, which takes into account the initial €3,300,861.52 investment.

Case 1 – Net Income for 3 Year Timeline

Category	Year 1	Year 2	Year 3	Total
EBIT	€ 2,739,917.25	€ 2,867,384.77	€ 2,846,897.40	€ 8,454,199.43
Taxes	€ 931,572.87	€ 974,911.82	€ 967,945.12	€ 2,874,429.81
Net Income	€ 1,808,425.39	€ 1,892,473.95	€ 1,878,952.28	€ 5,579,769.62
Totals	**€ 1,808,425.39**	**€ 1,892,473.95**	**€ 1,878,952.28**	**€ 5,579,769.62**

Table 51: Estimated Net Income for 3 Year Timeline for Case 1

Case 1 - Financial Performance

Metric	Value
NPV	€ 732,416.13
Initial Inv.	€ 3,300,861.52
Delta	€ 2,568,445.39
IRR	31.39%

Table 52: Estimated Financial Performance over 3 Years for Case 1

If the NPV = 0, then the discount rate of 18.03%, the targeted or "hurdle" rate of return will be achieved. In this case, the NPV is > 0 by €732,416.13, exceeding the threshold by 22.19% and the IRR is 31.39%.

That means that the net present value of the income stream *plus* recovery of the initial investment is more than the investment required, meaning that investment in Case 1 is recommended. The IRR (internal rate of return) also exceeds the discount rate, the investment return expected by the investor(s), thus Case 1 creates value.

To determine which combination of the four basic parameters (number of trainsets operated, load factor %, rate per kilometer and number of wagons), are optimal, a deeper analysis is necessary, accomplished through a sensitivity analysis using the data generated by the cost simulation tool, described further in this chapter.

As it stands, the present set of parameters with a train of 17 wagons with a load factor of 80% with the rate per km at €.90 would be profitable. The simulation tool results will show what combination of parameters determined in the sensitivity analysis will emerge on which to focus or enhance to maintain or enhance the profitability of Case 1.

6.2.4.2 Internal Rate of Return (IRR)

The IRR metric is used as an analysis tool to evaluate and compare business scenarios. The internal rate of return analysis measures the compound annual rate of return that a scenario will return over the three-year timeline, expressed as the actual percentage returns over time for funds invested today. Because the return is expressed as a percentage, this method is easy to compare to the cost of capital required.

The formula for IRR is as follows:

$$0 = CF_0 + \frac{CF_1}{(1+IRR)} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \ldots + \frac{CF_n}{(1+IRR)^n}$$

Or

$$0 = NPV = \sum_{n=0}^{N} \frac{CF_n}{(1+IRR)^n}$$

Where:
CF_0 = Initial Investment / Outlay
$CF_1, CF_2, CF_3 \ldots CF_n$ = Cash flows
n = Each Period
N = Holding Period
NPV = Net Present Value
IRR = Internal Rate of Return

Equation 4: Internal Rate of Return (IRR)
Source: Corporate Finance Institute

Once calculated, it is easy to determine if the case scenario's IRR equals or exceeds the required rate of return, expressed as the discount rate that converts the NPV of a series of cashflows equal to zero.

The disadvantage of this method is it assumes that the discount rate remains the same each year. If that rate changes, it is better to use the NPV method, though for such a short time span as in these case scenarios, it is less of a concern.

In any case, it makes sense to use both the NPV and IRR as tools to complement each other.

6.2.4.3 Breakeven Analysis

The break-even graphs show the volume points where cash flow turns positive for each case. The graphs are in section 6.3 The Case Analyses Application where the financial analysis of each of the eight cases is found.

6.2.4.4 Terminal Value

The terminal value can be expressed by the following formula:

Terminal Value = Final year projected cash flow * (1+ Infinite growth rate)/ (Discount rate - long term cash flow growth rate)

This value can involve a complicated set of calculations and assumes that the enterprise will continue indefinitely, which may or may not be so for any one or multiple of the case scenarios analyzed. In the terminal value calculation, one of the assumptions is that the company being analyzed will continue in perpetuity. It is beyond the scope of this research to apply this to any of these cases, which deliberately have a limited timeline, mainly to assess the profitability case for the first three years of operations. If the enterprise survives and prospers by and through the third year, the modified approach will be to determine the value of total retained earnings minus the initial investment and aggregate expenses incurred for the three-year period of operations to derive terminal value from that figure. If the scenario cases prove themselves commercially, then in further research, the value that will be used in the terminal value factor will be as described in the paragraph above.

For this thesis, however, the total accumulated retained earnings and initial investment recovered will constitute the terminal value.

6.2.5 Sensitivity Analysis – Step 7

6.2.5.1 Sensitivity Analysis

Various approaches to sensitivity analysis were considered.

One approach would be to exhaustively research going rates for rail and road transport in the target lanes of traffic. However, it is difficult to track moving targets with any stability, especially given today's risk uncertainties realized by the pandemic, war and aside from perpetually changing market forces.

A more certain technique involves examining ranges of historical rates per kilometer, in combination with the inputs of a range of load factors and train length. Those inputs, matched against the cost structure offer a more stable basis for comparison between scenarios, given these inputs. The outputs are expressed as ranges of net present values (NPV) and internal rates of return (IRR).

Once a realistic range of values is determined, one can select a freight rate to determine at what rate level the RU can operate profitably, given the estimated cost structure. The range of values is based on observed historical values over the last four years and is detailed further in **Section 6.3.1** and in **Appendix F: Sensitivity Analysis – Road Freight Rates**.

This analysis approach will achieve two goals in the analysis. First, it will compare a range of input scenarios within each case. Secondly, the analysis will reveal which combination of input scenarios *within* each case are optimal, given its cost structure. With that information, the analysis will offer insights into comparing the financial performance of each of the eight cases against each other on the same stable and consistent basis.

This will be the approach used for sensitivity analysis.

6.2.6 Recalibrate

Recalibrate after more information is known

More risks are known

Revisit market rates for service

6.2.7 Confirm Parameters

Confirm or reestablish new parameters for further analysis, when and if new data emerges.

6.3 The Case Analyses Application – Step 8

This section uses, as its foundation, the preliminary analyses conducted in Chapter 5, which established a base case of 17 wagons, a €.90 per kilometer rate and an 80% load factor.

In this chapter, the refined analysis of each case uses net present value (NPV), internal rate of return (IRR) and sensitivity analysis metrics to identify the best cases of overall financial performance of and within each of the cases, identify the optimum combination of train length, expressed as wagons, load factor, expressed as a percentage of loading units per train, based on wagons and rates per kilometer per loading unit.

As described earlier, the initial investment of each case will be equivalent to six months of fixed and variable expenses, with a 5% contingency.

The underlying assumptions and rationale for analysis is addressed in **Section 6.2.2 - Assumptions for Analysis – Step 1.** The discount rate applied to these cases will be 18.03%, with the rationale further summarized within the criteria outlined in **Section 6.2.3.4**.

6.3.1 Basis for Per Kilometer Base Rate

The underlying basis for the per kilometer base rate is derived from historical rates in the ***"European Road Freight Rate Development Benchmark Report – Q1-2020"*** compiled by Transportation Intelligence (**T*i*-Upply)** a British research firm.

T*i*-Upply publishes data on a granular level on numerous high-volume traffic lanes in Europe. Despite diminished demand through low European growth, the rates have remained higher for reasons, other than demand. Contributing are driver shortages, higher diesel fuel prices, tolls and other taxes. Between the lanes, there is often volatility, especially in high volume lanes.

The largest European road freight lane is between Duisburg Germany and Warsaw Poland. Between Q2 and Q3 2020, the average rate per km increased from €1.129 to €1.154.

Each of the cases include some portion of the route, linking either Rotterdam or Antwerp with Posnan or Wroclaw Poland, O/D pair routing, which includes these segments.

Taking the average of these two rates, which is approximately €1.11 on the upper bound of rail rates to be offered and applying an approximate common discount offered by RUs, as applied to prevailing trucking rates, yields an approximate rate of €.89, assuming a 20% discount applied to the general trucking rates. This defines the lower bound of rail rates to be a base of €.89 and the upper bound of rail rates to be €1.11, although the scale of the simulation model's slide bars spans from€.70 to €1.20 per kilometer. The graph and underlying data for this can be found in the **"*Duisburg - Warsaw Rd Freight Rates*"** tab of the spreadsheet tool.

6.3.2 Case 1 - Rotterdam – Wroclaw

In the preliminary analysis from Chapter 5, section 5.7.1, this case is profitable on a gross margin basis. Applying NPV and IRR calculations confirms the base case as positive. Considering an initial investment to capitalize the company at **€3,300,861.52** and an initial calculated NPV of the total revenue generated over three years of **€27,672,793** and a cumulative profit of **€5,579,772**, the recalculated NPV of this case is **€732,416.13.** and the IRR is **31.39%**, more than qualifying for investment grade, ranking second of all the cases. Under the base case scenario, the breakeven points in both trailers (loading units) and revenue are illustrated below.

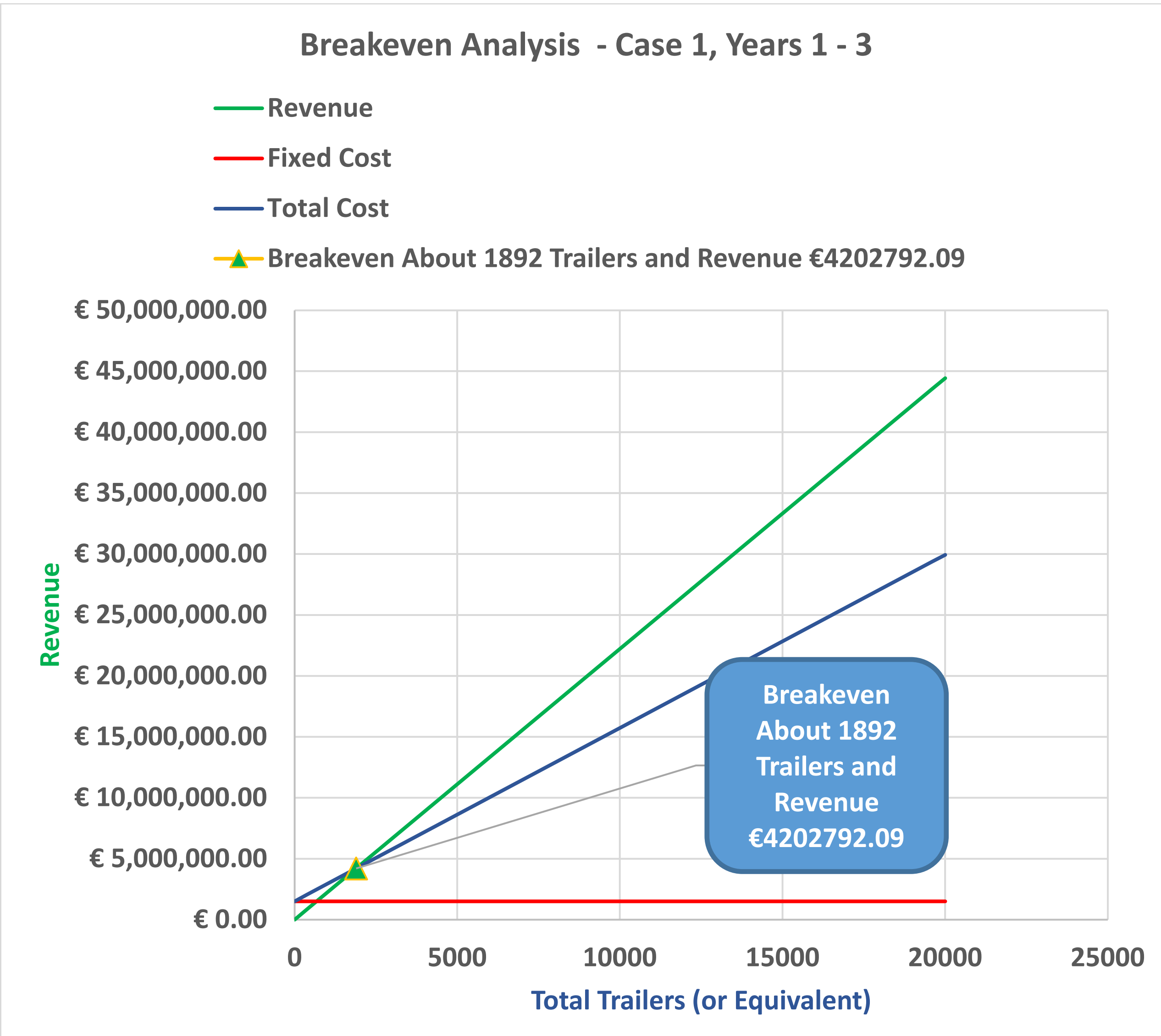


Figure 16: Breakeven Analysis - Case 1, Years 1 - 3

For Case 1, an overview of the NPV and IRR generated through the range of rates per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Cars	2 Trainsets		
Rate	Load Factor	NPV	IRR
€ 1.20	70%	€ 3,013,699.23	70.22%
€ 1.20	80%	€ 4,915,219.46	100.41%
€ 1.20	90%	€ 7,450,579.77	139.15%
€ 1.20	100%	€ 9,352,100.00	167.52%
€ 1.10	70%	€ 1,746,019.08	49.18%
€ 1.10	80%	€ 3,489,079.29	77.90%
€ 1.10	90%	€ 5,813,159.57	114.28%
€ 1.10	100%	€ 7,556,219.78	140.74%
€ 1.00	70%	€ 478,338.93	26.92%
€ 1.00	80%	€ 2,062,939.12	54.54%
€ 1.00	90%	€ 4,175,739.37	88.82%
€ 1.00	100%	€ 5,760,339.57	113.47%
€ 0.90	70%	-€ 789,341.22	2.48%
€ 0.90	80%	€ 636,798.95	29.79%
€ 0.90	90%	€ 2,538,319.18	62.44%
€ 0.90	100%	€ 3,964,459.35	85.48%
€ 0.80	70%	-€ 2,057,021.38	-26.80%
€ 0.80	80%	-€ 789,341.22	2.48%
€ 0.80	90%	€ 900,898.98	34.52%
€ 0.80	100%	€ 2,168,579.13	56.30%
€ 0.70	70%	-€ 3,346,719.11	
€ 0.70	80%	-€ 2,215,481.40	-31.18%
€ 0.70	90%	-€ 736,521.22	3.56%
€ 0.70	100%	€ 372,698.92	24.98%

Table 53: Case 1 Base Case Train Length Overview of NPV & IRR

This base case is compensatory and in the sensitivity analysis, the better performing scenarios emerged. They are, as follows:

17 Cars Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	€ 3,013,699.23	70.22%
€ 1.20	80%	€ 4,915,219.46	100.41%
€ 1.20	90%	€ 7,450,579.77	139.15%
€ 1.20	100%	€ 9,352,100.00	167.52%
€ 1.10	70%	€ 1,746,019.08	49.18%
€ 1.10	80%	€ 3,489,079.29	77.90%
€ 1.10	90%	€ 5,813,159.57	114.28%
€ 1.10	100%	€ 7,556,219.78	140.74%
€ 1.00	70%	€ 478,338.93	26.92%
€ 1.00	80%	€ 2,062,939.12	54.54%
€ 1.00	90%	€ 4,175,739.37	88.82%
€ 1.00	100%	€ 5,760,339.57	113.47%
€ 0.90	80%	€ 636,798.95	29.79%
€ 0.90	90%	€ 2,538,319.18	62.44%
€ 0.90	100%	€ 3,964,459.35	85.48%
€ 0.80	90%	€ 900,898.98	34.52%
€ 0.80	100%	€ 2,168,579.13	56.30%
€ 0.70	100%	€ 372,698.92	24.98%

Table 54: Sensitivity Table 17 Wagons Case 1 - Rotterdam – Wroclaw

Each of these scenarios are at the upper bounds of both rate and load factors and the few that are at lower rate per kilometer are at the highest load factors.

16 Cars Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	**€ 1,943,849.08**	**52.38%**
€ 1.20	80%	**€ 4,551,613.74**	**94.22%**
€ 1.20	90%	**€ 6,507,437.24**	**124.01%**
€ 1.20	100%	**€ 8,463,260.73**	**153.03%**
€ 1.10	70%	€ 748,623.61	31.76%
€ 1.10	80%	**€ 3,139,074.55**	**71.96%**
€ 1.10	90%	**€ 4,931,912.75**	**100.09%**
€ 1.10	100%	**€ 6,724,750.96**	**127.27%**
€ 1.00	80%	**€ 1,726,535.36**	**48.72%**
€ 1.00	90%	**€ 3,356,388.27**	**75.43%**
€ 1.00	100%	**€ 4,986,241.18**	**100.92%**
€ 0.90	80%	€ 313,996.17	23.88%
€ 0.90	90%	**€ 1,780,863.79**	**49.64%**
€ 0.90	100%	**€ 3,247,731.41**	**73.70%**
€ 0.80	90%	€ 55,778.88	19.08%
€ 0.80	100%	**€ 1,323,459.03**	**41.93%**

Table 55: Sensitivity Table 16 Wagons Case 1 - Rotterdam – Wroclaw

As with the 17-wagon matrix above, the 16-wagon scenario is similar, with profitability occupying the upper bounds of the load factor and rate range.

15 Cars Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	**€ 1,291,907.92**	**41.29%**
€ 1.20	80%	**€ 3,247,731.41**	**73.70%**
€ 1.20	90%	**€ 5,203,554.91**	**104.26%**
€ 1.20	100%	**€ 7,159,378.40**	**133.76%**
€ 1.10	70%	€ 151,010.88	20.86%
€ 1.10	80%	**€ 1,943,849.08**	**52.38%**
€ 1.10	90%	**€ 3,736,687.28**	**81.47%**
€ 1.10	100%	**€ 5,529,525.49**	**109.23%**
€ 1.00	80%	€ 639,966.75	29.81%
€ 1.00	90%	**€ 2,269,819.66**	**57.80%**
€ 1.00	100%	**€ 3,899,672.58**	**84.04%**
€ 0.90	90%	€ 802,952.04	32.72%
€ 0.90	100%	**€ 2,269,819.66**	**57.80%**
€ 0.80	100%	€ 639,966.75	29.81%

Table 56: Sensitivity Table 15 Wagons Case 1 - Rotterdam – Wroclaw

For the scenario with 15 wagons, the profitability is in the highest load factors and rates.

14 Cars Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	€ 639,966.75	29.81%
€ 1.20	80%	**€ 1,943,849.08**	**52.38%**
€ 1.20	90%	**€ 3,899,672.58**	**84.04%**
€ 1.20	100%	**€ 5,855,496.07**	**114.19%**
€ 1.10	80%	€ 748,623.61	31.76%
€ 1.10	90%	**€ 2,541,461.82**	**62.27%**
€ 1.10	100%	**€ 4,334,300.02**	**90.84%**
€ 1.00	90%	**€ 1,183,251.05**	**39.41%**
€ 1.00	100%	**€ 2,813,103.97**	**66.70%**
€ 0.90	100%	**€ 1,291,907.92**	**41.29%**

Table 57: Sensitivity Table 14 Wagons Case 1 - Rotterdam – Wroclaw

For trains with 14 wagons, the pattern repeats with profitability in the highest load factors and rates. These analyses identify the rate and load factor objectives for Case 1.

6.3.3 Case 2 - Antwerp - Wroclaw

In the *preliminary* analysis from Chapter 5, section 5.7.2, this case is profitable on a gross margin basis. However, those positive figures do not consider any taxes or initial startup costs and capital infusion. The total cash generated over three years is **€28,102,495,** with an initial investment to capitalize the company at **€3,502,634.** With an NPV of **€91,704**, combined with the IRR of **19.65%** this case is plausible.

Under the base case scenario, the high breakeven points in both trailers (loading units) and revenue are illustrated below. Note the high revenue and loading units (trailers) breakeven points.

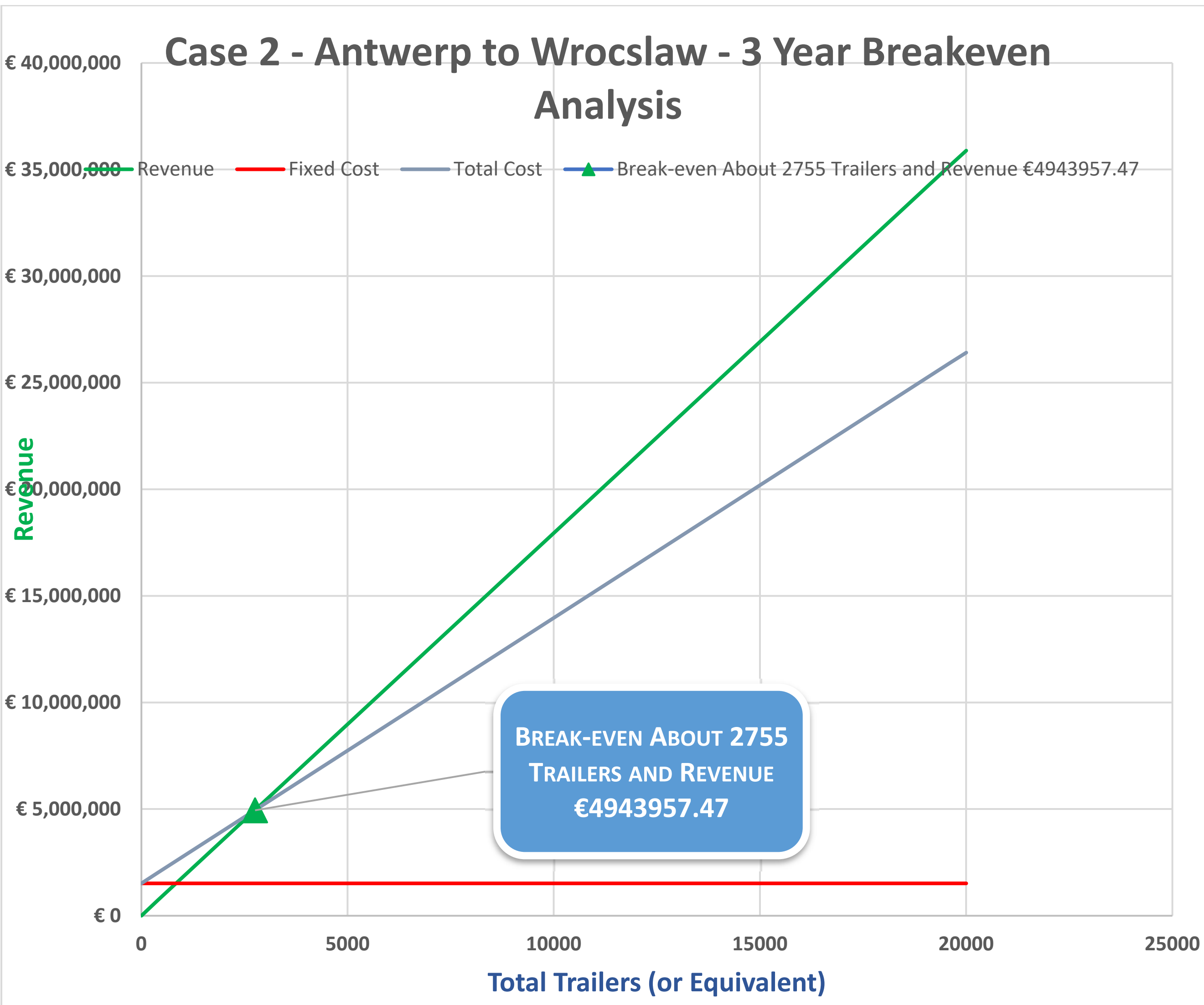


Figure 17: Breakeven Analysis - Case 2, Years 1 - 3

For Case 2, an overview of the NPV and IRR generated through the range of rate per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	**2,457,613.54**	**59.02%**
€ 1.20	80%	**4,350,341.19**	**88.35%**
€ 1.20	90%	**6,873,978.06**	**125.92%**
€ 1.20	100%	**8,766,705.71**	**153.39%**
€ 1.10	70%	**1,195,795.11**	**38.54%**
€ 1.10	80%	**2,930,795.45**	**66.48%**
€ 1.10	90%	**5,244,129.25**	**101.82%**
€ 1.10	100%	**6,979,129.60**	**127.46%**
€ 1.00	70%	-66,023.33	16.85%
€ 1.00	80%	**1,511,249.72**	**43.75%**
€ 1.00	90%	**3,614,280.44**	**77.10%**
€ 1.00	100%	**5,191,553.48**	**101.03%**
€ 0.90	70%	-1,327,841.76	-6.96%
€ 0.90	80%	91,703.98	19.65%
€ 0.90	90%	**1,984,431.63**	**51.45%**
€ 0.90	100%	**3,403,977.37**	**73.85%**
€ 0.80	70%	-2,598,479.08	-35.87%
€ 0.80	80%	-1,327,841.76	-6.96%
€ 0.80	90%	354,582.82	24.26%
€ 0.80	100%	**1,616,401.25**	**45.48%**
€ 0.70	70%	-4,190,700.66	N/A
€ 0.70	80%	-2,776,796.75	-41.28%
€ 0.70	90%	-1,275,265.99	-5.90%
€ 0.70	100%	-171,174.86	14.97%

Table 58: Case 2 Base Case Train Length Overview of NPV & IRR

The sensitivity analysis shows potential pockets of profitability for 17 wagons trains within each rate and load factor group.

17 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	**70%**	**€ 2,457,613.54**	**59.02%**
€ 1.20	**80%**	**€ 4,350,341.19**	**88.35%**
€ 1.20	**90%**	**€ 6,873,978.06**	**125.92%**
€ 1.20	**100%**	**€ 8,766,705.71**	**153.39%**
€ 1.10	**70%**	**€ 1,195,795.11**	**38.54%**
€ 1.10	**80%**	**€ 2,930,795.45**	**66.48%**
€ 1.10	**90%**	**€ 5,244,129.25**	**101.82%**
€ 1.10	**100%**	**€ 6,979,129.60**	**127.46%**
€ 1.00	**80%**	**€ 1,511,249.72**	**43.75%**
€ 1.00	**90%**	**€ 3,614,280.44**	**77.10%**
€ 1.00	**100%**	**€ 5,191,553.48**	**101.03%**
€ 0.90	80%	€ 91,703.98	19.65%
€ 0.90	**90%**	**€ 1,984,431.63**	**51.45%**
€ 0.90	**100%**	**€ 3,403,977.37**	**73.85%**
€ 0.80	90%	€ 354,582.82	24.26%
€ 0.80	**100%**	**€ 1,616,401.25**	**45.48%**
€ 1.20	**70%**	**€ 2,457,613.54**	**59.02%**

Table 59: Sensitivity Table 17 Wagons - Case 2

All of these scenarios are at the upper bounds of rate and especially load factors at the €1.10 rate with maximum wagons possible, illustrating a limited window of profitability.

16 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	**70%**	**€ 1,179,485.06**	**38.32%**
€ 1.20	**80%**	**€ 3,703,121.93**	**78.57%**
€ 1.20	**90%**	**€ 5,595,849.58**	**107.19%**
€ 1.20	**100%**	**€ 7,488,577.23**	**135.04%**
€ 1.10	70%	€ 22,818.16	18.44%
€ 1.10	**80%**	**€ 2,336,151.96**	**57.17%**
€ 1.10	**90%**	**€ 4,071,152.31**	**84.21%**
€ 1.10	**100%**	**€ 5,806,152.65**	**110.31%**
€ 1.00	80%	€ 969,181.99	34.80%
€ 1.00	**90%**	**€ 2,546,455.03**	**60.51%**
€ 1.00	**100%**	**€ 4,123,728.07**	**85.01%**
€ 0.90	**90%**	**€ 1,021,757.76**	**35.68%**
€ 0.90	**100%**	**€ 2,441,303.50**	**58.84%**
€ 0.80	100%	€ 758,878.92	31.23%

Table 60: Sensitivity Table 16 Wagons - Case 2

As above, most of the fourteen scenarios tend towards the upper bounds of rate and load factors and with only 16 wagons possible.

15 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	€ 532,265.80	27.38%
€ 1.20	**80%**	**€ 2,424,993.45**	**58.66%**
€ 1.20	**90%**	**€ 4,317,721.10**	**88.08%**
€ 1.20	**100%**	**€ 6,210,448.75**	**116.43%**
€ 1.10	**80%**	**€ 1,163,175.02**	**38.09%**
€ 1.10	**90%**	**€ 2,898,175.36**	**66.15%**
€ 1.10	**100%**	**€ 4,633,175.71**	**92.87%**
€ 1.00	**90%**	**€ 1,478,629.63**	**43.33%**
€ 1.00	**100%**	**€ 3,055,902.67**	**68.62%**
€ 0.90	100%	€ 59,083.89	19.08%
€ 0.90	**100%**	**€ 1,478,629.63**	**43.33%**

Table 61: Sensitivity Table 15 Wagons - Case 2

There are thirteen scenarios with 15 wagons that show profit at the upper bounds of rate, load factors, with a maximum of 15 wagons, with a narrower window of profitability.

14 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	**80%**	**€ 1,146,864.97**	**37.87%**
€ 1.20	**90%**	**€ 3,039,592.62**	**68.46%**
€ 1.20	**100%**	**€ 4,932,320.27**	**97.50%**
€ 1.10	**90%**	**€ 1,725,198.42**	**47.44%**
€ 1.10	**100%**	**€ 3,460,198.77**	**75.02%**
€ 1.00	90%	€ 410,804.22	25.29%
€ 1.00	**100%**	**€ 1,988,077.26**	**51.72%**
€ 0.90	100%	€ 515,955.76	27.12%

Table 62: Sensitivity Table 14 Wagons - Case 2

Trains with only fourteen wagons require high load factors and higher rates to be profitable.

6.3.4 Case 3 - Rotterdam - Posnan

This case showed initial promise, based on the preliminary gross profit figures in Chapter 5. Further analysis in applying the NPV and IRR metrics showed these results. For the base case of 17 wagons, €.90 per km and 80% load factor, over the three-year time-period, the total cash generated would be **€27,418,052,** with a net income of **€6,009,521**. With an initial investment to capitalize the company with **€3,147,137.39**, the NPV of the total cash flow over three years was **€1,189,512.69** and the IRR was **40.27%.** Of all the eight cases, Case 3 has the best financial performance, rating highest of all the cases. Under the base case scenario, the breakeven points in both trailers (loading units) and revenue are shown below.

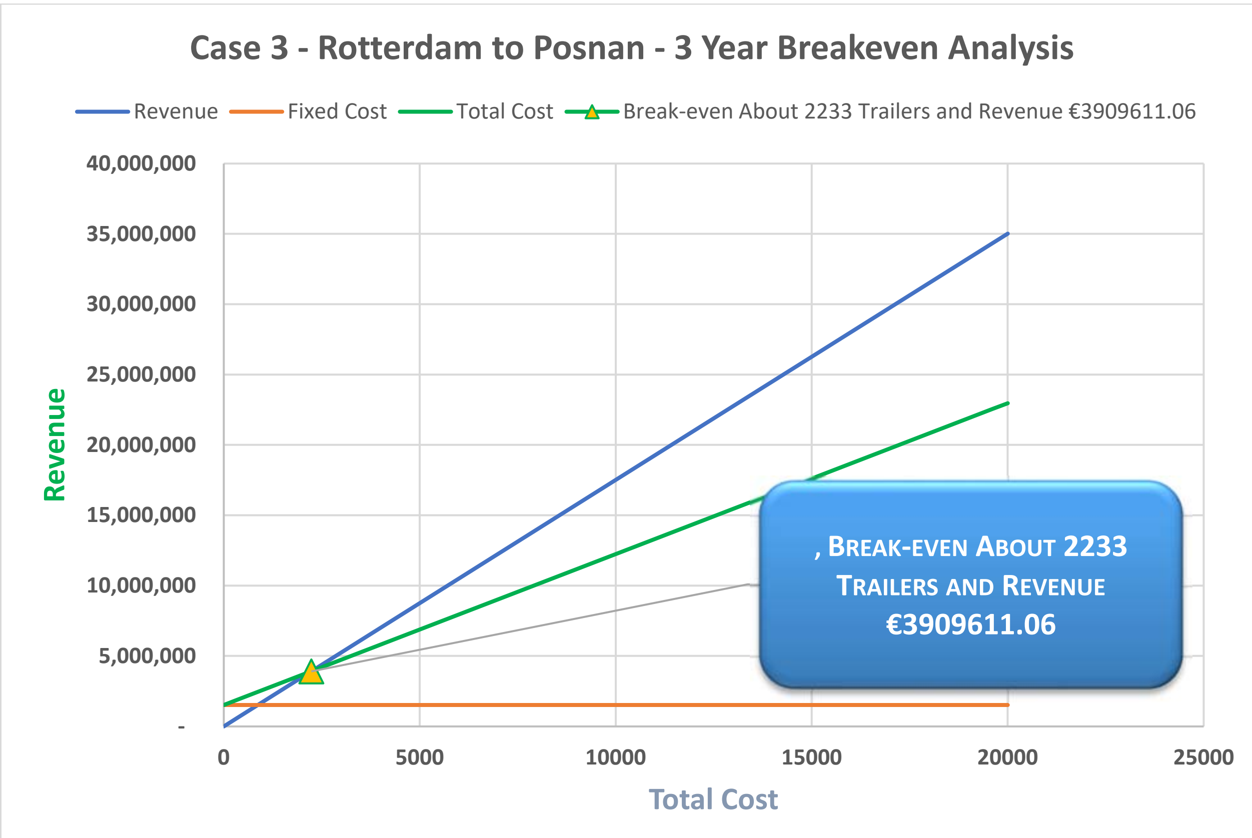


Figure 18: Breakeven Analysis - Case 3, Years 1 - 3

For Case 3, an overview of the NPV and IRR generated through the range of rates per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	3,610,539.09	81.61%
€ 1.20	80%	5,547,360.22	112.69%
€ 1.20	90%	8,129,788.38	152.68%
€ 1.20	100%	10,066,609.50	182.01%
€ 1.10	70%	2,319,325.01	60.04%
€ 1.10	80%	4,094,744.37	89.50%
€ 1.10	90%	6,461,970.19	127.00%
€ 1.10	100%	8,237,389.55	154.32%
€ 1.00	70%	1,028,110.93	37.36%
€ 1.00	80%	2,642,128.53	65.51%
€ 1.00	90%	4,794,152.00	100.74%
€ 1.00	100%	6,408,169.60	126.16%
€ 0.90	70%	-263,103.16	12.81%
€ 0.90	80%	1,189,512.69	40.27%
€ 0.90	90%	3,126,333.81	73.62%
€ 0.90	100%	4,578,949.65	97.30%
€ 0.80	70%	-1,554,317.24	-15.53%
€ 0.80	80%	-263,103.16	12.81%
€ 0.80	90%	1,458,515.62	45.08%
€ 0.80	100%	2,749,729.70	67.33%
€ 0.70	70%	-2,845,531.32	-57.21%
€ 0.70	80%	-1,715,719.00	-19.57%
€ 0.70	90%	-209,302.57	13.89%
€ 0.70	100%	920,509.75	35.40%

Table 63: Case 3 Base Case Train Length Overview of NPV & IRR

The sensitivity analysis shows the variable combinations s of potential profitability.

17 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	3,610,539.09	81.61%
€ 1.20	80%	5,547,360.22	112.69%
€ 1.20	90%	8,129,788.38	152.68%
€ 1.20	100%	10,066,609.50	182.01%
€ 1.10	70%	2,319,325.01	60.04%
€ 1.10	80%	4,094,744.37	89.50%
€ 1.10	90%	6,461,970.19	127.00%
€ 1.10	100%	8,237,389.55	154.32%
€ 1.00	70%	1,028,110.93	37.36%
€ 1.00	80%	2,642,128.53	65.51%
€ 1.00	90%	4,794,152.00	100.74%
€ 1.00	100%	6,408,169.60	126.16%
€ 0.90	80%	1,189,512.69	40.27%
€ 0.90	90%	3,126,333.81	73.62%
€ 0.90	100%	4,578,949.65	97.30%
€ 0.80	90%	1,458,515.62	45.08%
€ 0.80	100%	2,749,729.70	67.33%
€ 0.70	100%	920,509.75	35.40%

Table 64: Sensitivity Table 17 Wagons - Case 3

Many of these scenarios are at the upper bounds of either or both rate and load factors and with maximum wagons possible, although a profit can be generated with 70% load factor and also at as little as the €.80 and €.90 per km. level, albeit at higher load factors.

16 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	2,319,325.01	60.04%
€ 1.20	80%	4,901,753.17	102.46%
€ 1.20	90%	6,838,574.30	132.84%
€ 1.20	100%	8,775,395.42	162.51%
€ 1.10	70%	1,135,712.10	39.31%
€ 1.10	80%	3,502,937.92	79.84%
€ 1.10	90%	5,278,357.28	108.44%
€ 1.10	100%	7,053,776.64	136.17%
€ 1.00	80%	2,104,122.66	56.35%
€ 1.00	90%	3,718,140.27	83.37%
€ 1.00	100%	5,332,157.87	109.29%
€ 0.90	80%	705,307.41	31.44%
€ 0.90	90%	2,157,923.25	57.27%
€ 0.90	100%	3,610,539.09	81.61%
€ 0.80	90%	597,706.23	29.44%
€ 0.80	100%	1,888,920.32	52.63%
€ 0.70	100%	167,301.54	21.28%

Table 65: Sensitivity Table 16 Wagons - Case 3

Many of these scenarios are at the upper bounds of rate and/or load factors and with 16 wagons possible, although a profit can be generated with 70 - 80% load factor as little as the €.70 to €1.00 per km. level.

15 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	1,673,717.97	48.87%
€ 1.20	80%	3,610,539.09	81.61%
€ 1.20	90%	5,547,360.22	112.69%
€ 1.20	100%	7,484,181.34	142.80%
€ 1.10	70%	543,905.65	28.44%
€ 1.10	80%	2,319,325.01	60.04%
€ 1.10	90%	4,094,744.37	89.50%
€ 1.10	100%	5,870,163.74	117.76%
€ 1.00	80%	1,028,110.93	37.36%
€ 1.00	90%	2,642,128.53	65.51%
€ 1.00	100%	4,256,146.13	92.11%
€ 0.90	90%	1,189,512.69	40.27%
€ 0.90	100%	2,642,128.53	65.51%
€ 0.80	100%	1,028,110.93	37.36%

Table 66: Sensitivity Table 15 Wagons - Case 3

The scenarios listed above are generally at the maximum revenue and/or load factors for 15 wagons, indicating there is a prospect of generating a profit with only 15 wagons.

14 Wagons Rate	2 Trainsets Load Factor	NPV	IRR
€ 1.20	70%	1,028,110.93	37.36%
€ 1.20	80%	2,319,325.01	60.04%
€ 1.20	90%	4,256,146.13	92.11%
€ 1.20	100%	6,192,967.26	122.81%
€ 1.10	80%	1,135,712.10	39.31%
€ 1.10	90%	2,911,131.46	70.03%
€ 1.10	100%	4,686,550.83	99.02%
€ 1.00	90%	1,566,116.79	46.98%
€ 1.00	100%	3,180,134.40	74.51%
€ 0.90	90%	221,102.13	22.32%
€ 0.90	100%	1,673,717.97	48.87%
€ 0.80	100%	167,301.54	21.28%

Table 67: Sensitivity Table 14 Wagons

The scenarios listed above are generally at the maximum revenue and/or load factors for 14 wagons, similar to a 15-wagon train, except that the NPV and IRR is generally lower.

6.3.5 Case 4 - Antwerp - Posnan

In the original preliminary analysis, for gross margin, this case showed a slight loss for the first year and good profits for the second and third year. A more thorough analysis, applying the NPV and IRR metrics showed the following results**.** With an initial investment to capitalize the company with **€3,453,365.25**, the NPV of the total cash flow over three years was **€428,394.04** and the IRR was **25.58%.** Over the three-year time-period, the total cash generated would be **€28,217,082, with a net income of €5,371,719.** Ranking third amongst all the cases, it is an investable scenario. Under the base case scenario, the breakeven points in both trailers (loading units) and revenue are illustrated below.

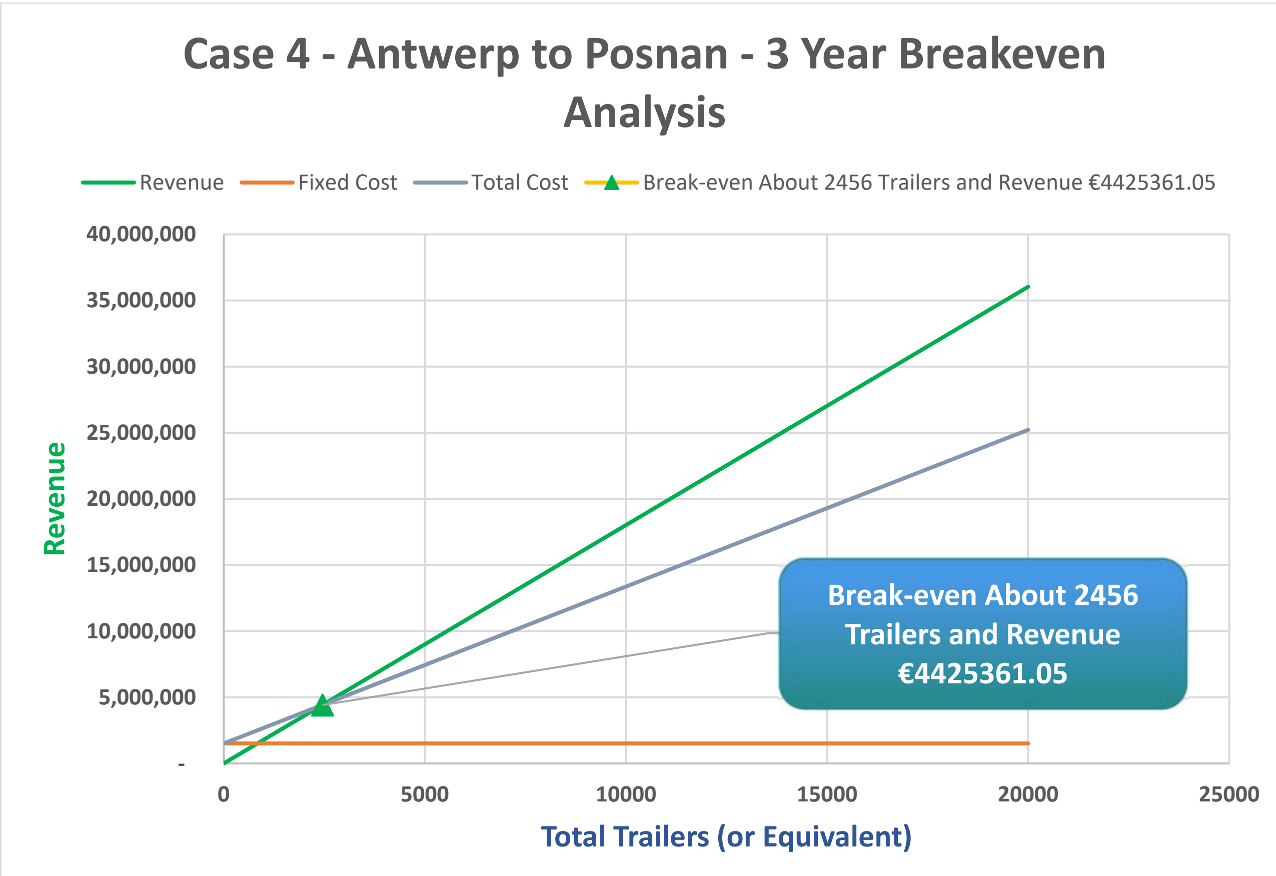


Figure 19: Breakeven Analysis - Case 4, Years 1 - 3

For Case 4, an overview of the NPV and IRR generated through the range of rates per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Wagons Rate	Load Factor	NPV	IRR
€ 1.20	70%	€ 2,921,259.13	66.06%
€ 1.20	80%	€ 4,915,551.21	96.02%
€ 1.20	90%	€ 7,574,607.30	134.27%
€ 1.20	100%	€ 9,568,899.38	162.19%
€ 1.10	70%	€ 1,591,731.08	45.06%
€ 1.10	80%	€ 3,419,832.15	73.69%
€ 1.10	90%	€ 5,857,300.24	109.73%
€ 1.10	100%	€ 7,685,401.31	135.83%
€ 1.00	70%	€ 262,203.03	22.68%
€ 1.00	80%	€ 1,924,113.10	50.41%
€ 1.00	90%	€ 4,139,993.18	84.53%
€ 1.00	100%	€ 5,801,903.24	108.93%
€ 0.90	70%	-€ 1,067,325.02	-2.18%
€ 0.90	80%	€ 428,394.04	25.58%
€ 0.90	90%	€ 2,422,686.11	58.31%
€ 0.90	100%	€ 3,918,405.17	81.22%
€ 0.80	70%	-€ 2,396,853.06	-32.98%
€ 0.80	80%	-€ 1,067,325.02	-2.18%
€ 0.80	90%	€ 705,379.05	30.34%
€ 0.80	100%	€ 2,034,907.10	52.18%
€ 0.70	70%	-€ 3,867,077.16	N/A
€ 0.70	80%	-€ 2,563,044.07	-37.79%
€ 0.70	90%	-€ 1,011,928.01	-1.07%
€ 0.70	100%	€ 151,409.03	20.73%

Table 68: Case 4 Base Case Train Length Overview of NPV & IRR

The sensitivity analysis shows what combination of the variables could be profitable in Case 4.

17 Wagons Rate	Load Factor	NPV	IRR
€ 1.20	70%	**€ 2,921,259.13**	**66.06%**
€ 1.20	80%	**€ 4,915,551.21**	**96.02%**
€ 1.20	90%	**€ 7,574,607.30**	**134.27%**
€ 1.20	100%	**€ 9,568,899.38**	**162.19%**
€ 1.10	70%	**€ 1,591,731.08**	**45.06%**
€ 1.10	80%	**€ 3,419,832.15**	**73.69%**
€ 1.10	90%	**€ 5,857,300.24**	**109.73%**
€ 1.10	100%	**€ 7,685,401.31**	**135.83%**
€ 1.00	70%	€ 262,203.03	22.68%
€ 1.00	80%	**€ 1,924,113.10**	**50.41%**
€ 1.00	90%	**€ 4,139,993.18**	**84.53%**
€ 1.00	100%	**€ 5,801,903.24**	**108.93%**
€ 0.90	80%	€ 428,394.04	25.58%
€ 0.90	90%	**€ 2,422,686.11**	**58.31%**
€ 0.90	100%	**€ 3,918,405.17**	**81.22%**
€ 0.80	90%	€ 705,379.05	30.34%
€ 0.80	100%	**€ 2,034,907.10**	**52.18%**
€ 0.70	100%	€ 151,409.03	20.73%

Table 69: Sensitivity Table 17 Wagons - Case 4

All six of these scenarios are at the upper bounds of both rate and load factors and with maximum wagons possible.

16 Wagons Rate	Load Factor	NPV	IRR
€ 1.20	70%	€ 1,591,731.08	45.06%
€ 1.20	80%	€ 4,250,787.18	86.19%
€ 1.20	90%	€ 6,245,079.25	115.32%
€ 1.20	100%	€ 8,239,371.33	143.63%
€ 1.10	70%	€ 372,997.04	24.62%
€ 1.10	80%	€ 2,810,465.13	64.35%
€ 1.10	90%	€ 4,638,566.20	91.94%
€ 1.10	100%	€ 6,466,667.26	118.50%
€ 1.00	80%	€ 1,370,143.07	41.45%
€ 1.00	90%	€ 3,032,053.14	67.76%
€ 1.00	100%	€ 4,693,963.20	92.75%
€ 0.90	90%	€ 1,425,540.08	42.35%
€ 0.90	100%	€ 2,921,259.13	66.06%
€ 0.80	100%	€ 1,148,555.07	37.79%

Table 70: Sensitivity Table 16 Wagons - Case 4

These scenarios with 16 wagons are profitable, generally at the upper bounds for rates and load factors.

15 Wagons Rate	Load Factor	NPV	IRR
€ 1.20	70%	€ 926,967.06	34.09%
€ 1.20	80%	€ 2,921,259.13	66.06%
€ 1.20	90%	€ 4,915,551.21	96.02%
€ 1.20	100%	€ 6,909,843.28	124.83%
€ 1.10	80%	€ 1,591,731.08	45.06%
€ 1.10	90%	€ 3,419,832.15	73.69%
€ 1.10	100%	€ 5,247,933.22	100.88%
€ 1.00	80%	€ 262,203.03	22.68%
€ 1.00	90%	€ 1,924,113.10	50.41%
€ 1.00	100%	€ 3,586,023.16	76.21%
€ 0.90	90%	€ 428,394.04	25.58%
€ 0.90	100%	€ 1,924,113.10	50.41%
€ 0.80	100%	€ 262,203.03	22.68%

Table 71: Sensitivity Table 15 Wagons - Case 4

Predictably, the possibilities of Case 4 with 15 wagons to achieve profitability is with these scenarios at the upper range limits of the variables.

14 Wagons Rate	Load Factor	NPV	IRR
€ 1.20	70%	€ 332,738.94	23.95%
€ 1.20	80%	€ 1,662,266.99	46.35%
€ 1.20	90%	€ 3,656,559.07	77.58%
€ 1.20	100%	€ 5,650,851.14	107.20%
€ 1.10	80%	€ 443,532.95	25.89%
€ 1.10	90%	€ 2,271,634.02	56.13%
€ 1.10	100%	€ 4,099,735.08	84.27%
€ 1.00	90%	€ 886,708.96	33.50%
€ 1.00	100%	€ 2,548,619.03	60.50%
€ 0.90	100%	€ 997,502.97	35.37%

Table 72: Sensitivity Table 15 Wagons - Case 4

Similarly, the possibilities of Case 4 with 14 wagons to achieve profitability shrink with these scenarios at the even further upper range limits of the variables.

This case with only 14 wagons, with the base rate of €.90 per km and 80% load factor does not represent a good investment, as profitability is not achieved with such high rates, compared to trucks, along with a low load factor. The range of parameters depicted above are too narrow a range of scenarios that are unrealistic to achieve. It's harder to get 100% load factor or even 90% and profitability is achieved at rates close to what trucks charge. If rail rates are nearly identical to truck, the shipper will almost always select truck.

6.3.6 Case 5 - Rotterdam – (Forst) - Wroclaw

The initial assessment of Case 5 from the preliminary analysis in Chapter 5 was that losses for each of the three years increased progressively to a cumulative loss of -€2,489,581 in gross margin. The reason for this was high costs incurred by short trains at the border crossings between Netherlands and Germany, the requirement by DB Netz, the German infrastructure authority to be able to use only a diesel locomotive to/from Forst and higher labor costs, resulting from the excessive time required by using the routes available in Germany and the Netherlands.

This scenario uses trucks for the short segment to/from Poland because their infrastructure authorities will not allow train lengths of more than 630 meters on their network, reducing the profitability of rail operations in Poland. This resulted in investigating the use of trucks. After re-analyzing the base case, the findings are now positive for this iteration. The initial capital to fund the enterprise is **€3,880,473**. The NPV value for three years is **€241,330** and the IRR is -**21.87%.** Over a three-year span, this case generates gross revenue of **€31,276,068.**

From the base case scenario, the breakeven points in both trailers (loading units) and revenue are illustrated below. In this case, there is a separate round trip truck segment from Forst to Wroclaw to complete the trip is priced as the same rate as rail, as the RU will be assumed to offer the same through rate, with the increased cost of trucking is absorbed in the RU costs.

In summary, the base case of 17 wagons, with an 80% load factor and priced at €.90 per km per loading unit through rate in the Rotterdam to Wroclaw corridor is profitable. As can be seen in running simulations, as the load factor and price charged per km increase, the business case also improves.

As a test case in applying a multiple of 1.2 or 20%, accounting for the increased costs for truck to the revenue figure, as well, changes the financial performance of this case negatively. When the multiple of 1.2 is also applied to revenue, the difference is near parity from no additive.

The NPV value for three years decreases to **€40,915,** and the IRR decreases slightly to **18.65%.** Over a three-year span, this case then generates a total gross revenue of **€32,439,127**, a positive difference of **€1,163,059** more.

In terms of net income over 3 years, the Case 5 scenario without the 20% truck revenue is €5,693,906 and with the 20% truck revenue and 20% truck costs added, the net income over 3 years decreases to €5,691,406, a negative difference of €2500, which is negligible. To realize a profit from the truck-related additives, the additional truck revenue must exceed the truck costs. The cost simulation model allows experimenting with different combinations, based on dynamic market conditions to arrive at realistic rate scenarios. Case 5 is the best performer of all the cases with truck (Cases 5 – 8), operating profitably.

Note that applying the truck revenue and expense multiple of 1.2 to the base case, the breakeven trailers/loading units increased by three units from 2358 to 2359 units and the breakeven revenue increases from €4,709,385 to €4,886,584, a 3.76% difference. The significance of this is that the 20% increase in additional revenue is mostly offset by an additional 20% in costs.

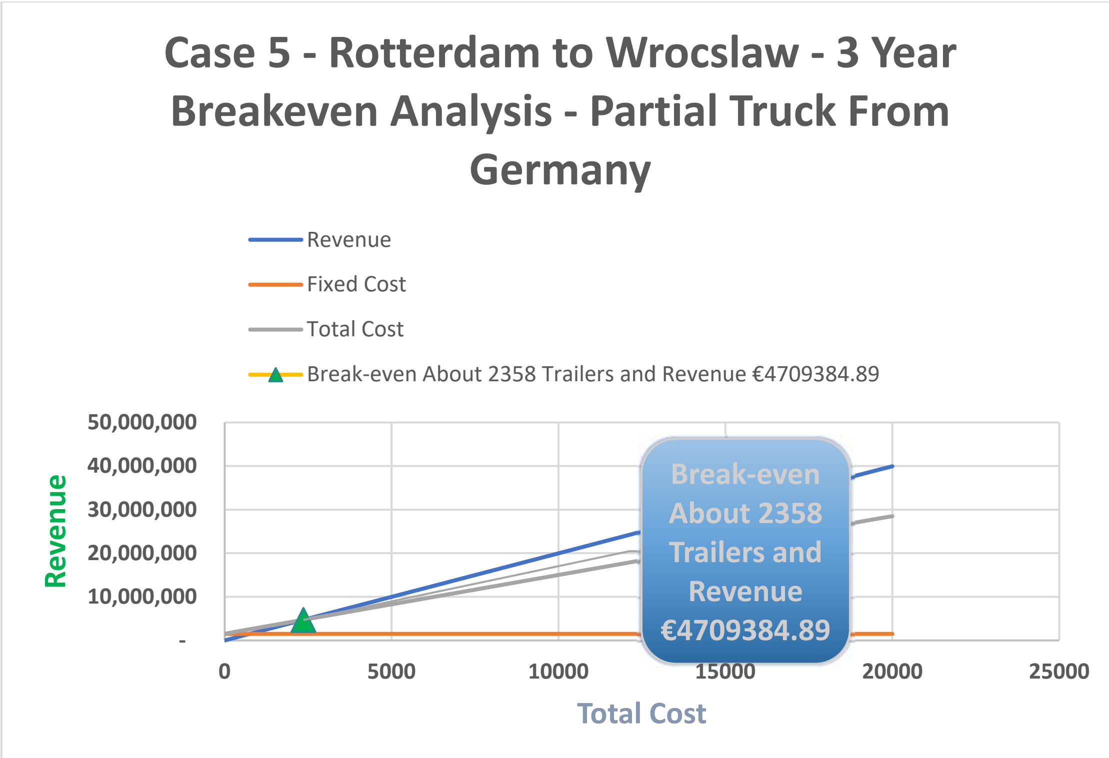


Figure 20: Breakeven Analysis - Case 5, Years 1 – 3 without truck revenue multiple of 1.2

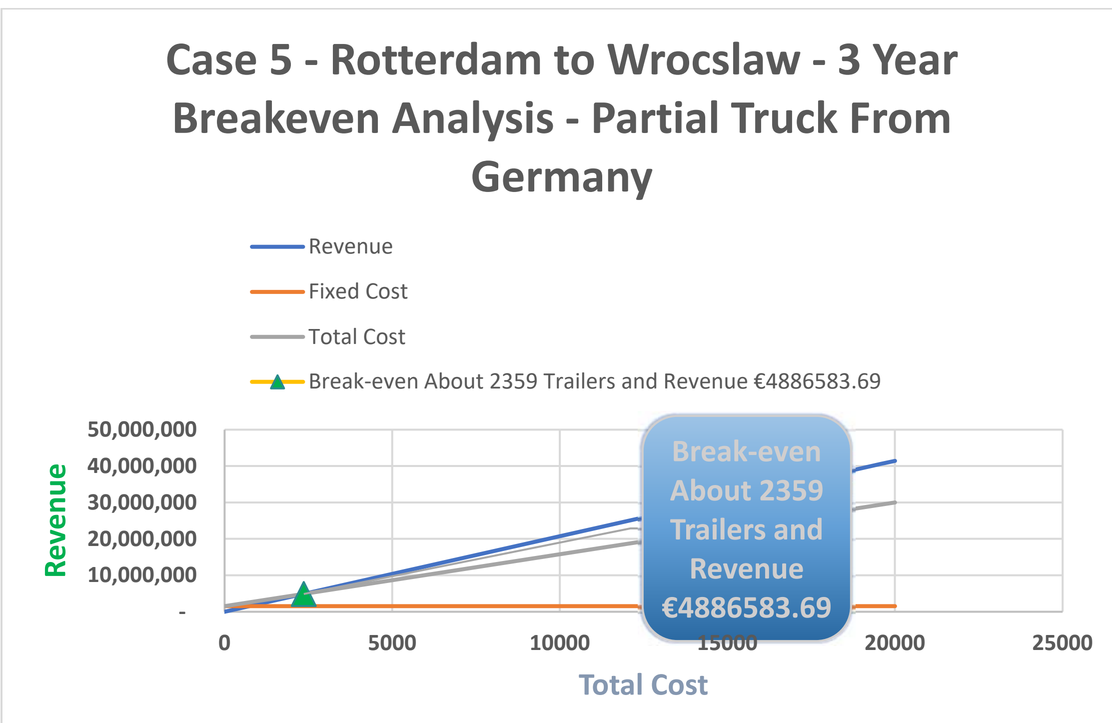


Figure 21**:** Breakeven Analysis - Case 5, Years 1 – 3 with truck revenue multiple of 1.2

For Case 5, the NPV and IRR values generated through the ranges of rates per km and load factors by a base case train length of 17 wagons is shown in the next below and shows what combination of the variables could be profitable.

17 Wagons			
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	70%	-€ 1,098,810.28	3.63%
€ 1.20	80%	€ 534,283.58	24.49%
€ 1.20	90%	**€ 2,711,742.07**	**48.22%**
€ 1.20	100%	**€ 4,344,835.93**	**63.99%**
€ 1.10	70%	**-€ 2,187,539.52**	**-12.76%**
€ 1.10	80%	-€ 690,536.81	9.18%
€ 1.10	90%	**€ 1,305,466.80**	**33.32%**
€ 1.10	100%	€ 2,802,469.51	49.14%
€ 1.00	70%	-€ 3,276,268.76	-33.03%
€ 1.00	80%	-€ 1,915,357.21	-8.40%
€ 1.00	90%	-€ 100,808.47	16.78%
€ 1.00	100%	**€ 1,260,103.08**	**32.82%**
€ 0.90	70%	-€ 4,364,998.00	-66.60%
€ 0.90	80%	-€ 3,140,177.61	-30.15%
€ 0.90	90%	-€ 1,507,083.74	-2.21%
€ 0.90	100%	-€ 282,263.35	14.49%
€ 0.80	70%	-€ 5,912,975.14	N/A
€ 0.80	80%	-€ 4,364,998.00	-66.60%
€ 0.80	90%	-€ 2,913,359.01	-25.62%
€ 0.80	100%	-€ 1,824,629.77	-6.99%
€ 0.70	70%	-€ 7,613,162.84	N/A
€ 0.70	80%	-€ 6,125,498.60	N/A
€ 0.70	90%	-€ 4,319,634.28	-64.23%
€ 0.70	100%	-€ 3,366,996.20	-35.03%

Table 73: Case 5 W/No Additive for Truck Revenue

17 Wagons	with Added Truck Revenue		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	70%	-€ 1,336,339.38	1.19%
€ 1.20	80%	€ 267,063.34	21.12%
€ 1.20	90%	**€ 2,404,933.64**	**43.55%**
€ 1.20	100%	**€ 4,008,336.37**	**58.31%**
€ 1.10	70%	-€ 2,405,274.53	-14.60%
€ 1.10	80%	-€ 935,488.70	6.51%
€ 1.10	90%	**€ 1,024,225.74**	**29.50%**
€ 1.10	100%	-€ 2,405,274.53	-14.60%
€ 1.00	70%	-€ 3,474,209.68	-34.28%
€ 1.00	80%	-€ 2,138,040.74	-10.39%
€ 1.00	90%	-€ 356,482.16	13.78%
€ 1.00	100%	€ 979,686.78	29.02%
€ 0.90	70%	-€ 4,543,144.83	-67.26%
€ 0.90	80%	-€ 3,340,592.79	-31.47%
€ 0.90	90%	-€ 1,737,190.06	-4.42%
€ 0.90	100%	-€ 534,638.02	11.59%
€ 0.80	70%	-€ 6,071,946.83	N/A
€ 0.80	80%	-€ 4,543,144.83	-67.26%
€ 0.80	90%	-€ 3,117,897.96	-27.07%
€ 0.80	100%	-€ 2,048,962.81	-9.03%
€ 0.70	70%	-€ 7,752,263.07	N/A
€ 0.70	80%	-€ 6,281,986.36	N/A
€ 0.70	90%	-€ 4,498,605.87	-64.91%
€ 0.70	100%	-€ 3,563,287.61	-36.23%

Table 74: Case 5 with 20% Additive for Truck Cost & Revenue

The sensitivity analysis shows what combination of the variables could be profitable in Case 5.

17 Wagons Rate	with Added Truck Revenue Load Factor	NPV	IRR
€ 1.20	80%	€ 267,063.34	21.12%
€ 1.20	90%	**€ 2,404,933.64**	**43.55%**
€ 1.20	100%	**€ 4,008,336.37**	**58.31%**
€ 1.10	90%	**€ 1,024,225.74**	**29.50%**
€ 1.00	100%	€ 979,686.78	29.02%

Table 75: Sensitivity Table 17 Wagons - Case 5

All seventeen of these scenarios are at the upper bounds of either or both rate and load factors and with maximum wagons possible.

16 Wagons Rate	with Added Truck Revenue Load Factor	NPV	IRR
€ 1.20	90%	**€ 1,335,998.49**	**32.80%**
€ 1.20	100%	**€ 2,939,401.22**	**48.64%**
€ 1.10	90%	€ 44,368.52	18.55%
€ 1.10	100%	**€ 1,514,154.35**	**34.65%**
€ 1.00	100%	€ 88,907.48	19.07%

Table 76: Sensitivity Table 16 Wagons - Case 5

The 16 wagon trains are only profitable at the rate of €1 - 1.20 per kilometer and from the 90% to 100% load factors.

15 Wagons Rate	with Added Truck Revenue Load Factor	NPV	IRR
€ 1.20	90%	€ 267,063.34	21.12%
€ 1.20	100%	**€ 1,870,466.07**	**38.28%**
€ 1.10	100%	€ 534,297.13	24.14%

Table 77: Sensitivity Table 15 Wagons - Case 5

At only the highest rate and load factors are 15 wagon trains profitable.

14 Wagons Rate	with Added Truck Revenue Load Factor	NPV	IRR
€ 1.20	100%	**€ 801,530.92**	**27.09%**

Table 78: Sensitivity Table – 14 Wagons – Case 5

At only the highest rate and load factor is a 14 wagon train profitable.

6.3.7 Case 6 – Antwerp – (Forst) - Wroclaw

This case suffers the heaviest of losses of all, because the infrastructure costs to the Port of Antwerp (Combinant) are quite high. This is partially due to the circuitous characteristics of the infrastructure path(s) and the high energy cost incurred by the necessity to use a diesel vs. electric locomotive for these routes. The problem is in the routing from Germany and through Belgium. Either way, the line to/from the port is electrified, but follows a meandering, circuitous path, with relatively low energy costs, but higher transit times, resulting in high labor costs, as well as the higher cost of the longer path itself.

This case uses trucks for the short segment to/from Poland because the Polish infrastructure authorities will not allow train lengths of more than 630 meters on their network, reducing the profitability of rail operations in Poland. This resulted in investigating alternatives, which meant using trucks. After re-analyzing the base case, the findings are negative for this iteration and it ranks last of the eight cases. This iteration, Case 6, will include a 1.20 multiple for both truck costs and revenue for the short portion to/from Poland.

Based on the truck multiple described above, the initial capital to fund the enterprise is **€4,533,785** and the NPV value for three years is **-€811,727** and the IRR is **6.57%**. There is a separate round trip and the truck segment from Forst-Wroclaw-Forst is priced 1.2 X the rail rate. The total amount of revenue generated by this case over 3 years is **€34,274,731** and total net income over three years is **€3,428,300.**

This case rates eighth of all cases and last place in Cases 5 – 8, involving trucks.

The base case scenario with the breakeven points for both trailers (loading units) and revenue are illustrated in **Figure 22**, below.

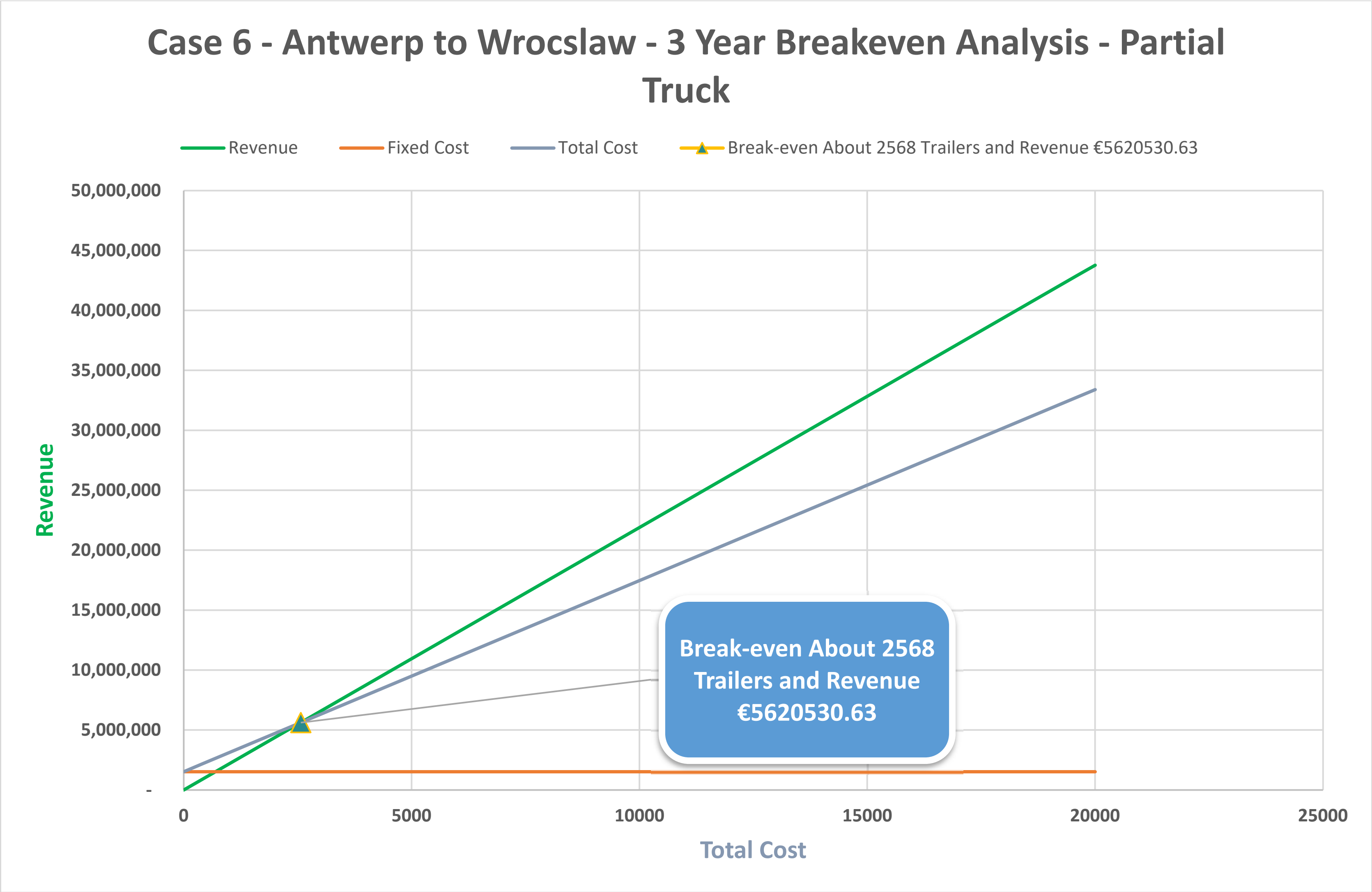


Figure 22: Breakeven Analysis - Case 6, Years 1 – 3

For Case 6, an overview of the NPV and IRR generated through the range of rates per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Wagons	**with 1.2 Truck Cost and Revenue Applied**		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	**70.00%**	-€ 2,979,021.58	-16.82%
€ 1.20	**80.00%**	-€ 1,227,948.97	5.04%
€ 1.20	**90.00%**	**€ 1,106,814.51**	**28.67%**
€ 1.20	**100.00%**	**€ 2,857,887.12**	**43.99%**
€ 1.10	**70.00%**	-€ 4,146,403.32	-35.62%
€ 1.10	**80.00%**	-€ 2,541,253.42	-10.85%
€ 1.10	**90.00%**	-€ 401,053.57	13.94%
€ 1.10	**100.00%**	**€ 1,204,096.32**	**29.57%**
€ 1.00	**70.00%**	-€ 5,313,785.05	-66.72%
€ 1.00	**80.00%**	-€ 3,854,557.88	-30.39%
€ 1.00	**90.00%**	-€ 1,908,921.65	-2.88%
€ 1.00	**100.00%**	-€ 449,694.47	13.44%
€ 0.90	**70.00%**	-€ 6,961,715.05	N/A
€ 0.90	**80.00%**	-€ 5,167,862.34	-60.78%
€ 0.90	**90.00%**	-€ 3,416,789.73	-23.28%
€ 0.90	**100.00%**	-€ 2,103,485.27	-5.26%
€ 0.80	**70.00%**	-€ 8,791,192.78	N/A
€ 0.80	**80.00%**	-€ 6,961,715.05	N/A
€ 0.80	**90.00%**	-€ 4,924,657.81	-53.09%
€ 0.80	**100.00%**	-€ 3,757,276.07	-28.74%
€ 0.70	**70.00%**	-€ 10,620,670.51	N/A
€ 0.70	**80.00%**	-€ 9,019,877.50	N/A
€ 0.70	**90.00%**	-€ 6,885,486.81	N/A
€ 0.70	**100.00%**	-€ 5,411,066.87	-71.87%

Table 79: Case 6 Base Case Train Length Overview of NPV & IRR

The sensitivity analysis shows what combination of the variables could be profitable in Case 6.

17 Wagons	with 1.2 Truck Cost and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	70.00%	€ 6,991,132.56	48.30%
€ 1.20	80.00%	€ 12,244,350.38	67.58%
€ 1.20	**90.00%**	**€ 19,248,640.82**	**90.18%**
€ 1.20	**100.00%**	**€ 24,501,858.65**	**105.33%**
€ 1.10	70.00%	€ 3,488,987.34	33.95%
€ 1.10	80.00%	€ 8,304,437.01	53.35%
€ 1.10	**90.00%**	**€ 14,725,036.58**	**75.94%**
€ 1.10	**100.00%**	**€ 19,540,486.25**	**91.06%**
€ 1.00	80.00%	€ 4,364,523.64	37.68%
€ 1.00	90.00%	€ 10,201,432.34	60.36%
€ 1.00	**100.00%**	**€ 14,579,113.86**	**75.46%**
€ 0.90	80.00%	€ 424,610.27	20.07%
€ 0.90	90.00%	€ 5,677,828.10	43.08%
€ 0.90	100.00%	€ 9,617,741.47	58.24%
€ 0.80	90.00%	€ 1,154,223.86	23.51%
€ 0.80	100.00%	€ 4,656,369.08	38.89%

Table 80: Sensitivity Table 17 Wagons - Case 6

Nearly each of the scenarios for a 17-wagon train are near or at the upper bounds of rate and load factor.

16 Wagons	with 1.2 Truck Cost and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	70.00%	€ 3,488,987.34	33.95%
€ 1.20	80.00%	€ 10,493,277.77	61.41%
€ 1.20	**90.00%**	**€ 15,746,495.60**	**79.27%**
€ 1.20	**100.00%**	**€ 20,999,713.43**	**95.38%**
€ 1.10	70.00%	€ 278,687.56	19.38%
€ 1.10	80.00%	€ 6,699,287.12	47.16%
€ 1.10	**90.00%**	**€ 11,514,736.80**	**65.04%**
€ 1.10	**100.00%**	**€ 16,330,186.47**	**81.14%**
€ 1.00	80.00%	€ 2,905,296.47	31.42%
€ 1.00	90.00%	€ 7,282,977.99	49.44%
€ 1.00	**100.00%**	**€ 11,660,659.51**	**65.55%**
€ 0.90	90.00%	€ 3,051,219.19	32.06%
€ 0.90	100.00%	€ 6,991,132.56	48.30%
€ 0.80	100.00%	€ 2,321,605.60	28.83%

Table 81: Sensitivity Table 16 Wagons - Case 6

All the profitable scenarios for a train of 16 wagons are at the upper limits of rates per kilometer and load factors.

15 Wagons	with 1.2 Truck Costs and Revenue Applied		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	70.00%	€ 1,737,914.73	26.20%
€ 1.20	80.00%	€ 6,991,132.56	48.30%
€ 1.20	**90.00%**	**€ 12,244,350.38**	**67.58%**
€ 1.20	**100.00%**	**€ 17,497,568.21**	**84.81%**
€ 1.10	80.00%	€ 3,488,987.34	33.95%
€ 1.10	90.00%	€ 8,304,437.01	53.35%
€ 1.10	**100.00%**	**€ 13,119,886.69**	**70.58%**
€ 1.00	90.00%	€ 4,364,523.64	37.68%
€ 1.00	100.00%	€ 8,742,205.17	55.00%
€ 0.90	90.00%	€ 424,610.27	20.07%
€ 0.90	100.00%	€ 4,364,523.64	37.68%

Table 82: Sensitivity Table 15 Wagons - Case 6

All the profitable scenarios for a train of 15 wagons are at the upper limit of load factor either/or rate per kilometer.

14 Wagons	with 1.2 Truck Costs and Revenue Applied		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	80.00%	€ 3,488,987.34	33.95%
€ 1.20	90.00%	€ 8,742,205.17	55.00%
€ 1.20	**100.00%**	**€ 13,995,422.99**	**73.53%**
€ 1.10	80.00%	€ 278,687.56	19.38%
€ 1.10	90.00%	€ 5,094,137.23	40.71%
€ 1.10	**100.00%**	**€ 9,909,586.90**	**59.30%**
€ 1.00	90.00%	€ 1,446,069.29	24.86%
€ 1.00	100.00%	€ 5,823,750.82	43.67%
€ 0.90	100.00%	€ 1,737,914.73	26.20%

Table 83: Sensitivity Table 14 Wagons - Case 6

All the profitable scenarios for a train of 14 wagons are at the upper limit of load factor either/or rate per kilometer and even more so than a t a 15-wagon train.

6.3.8 Case 7 – Antwerp – (Forst) - Posnan

This case uses trucks for the short segment to/from Poland from the German border because the Polish infrastructure authorities will not allow train lengths of more than 630 meters on their network, reducing the profitability of rail operations in Poland. This resulted in investigating alternatives, which meant using trucks. After re-analyzing the base case, the findings are negative for this iteration and it performs poorer than Cases 5 and 8, using trucks and ranking seventh in financial performance of all the cases. The initial capital to fund the enterprise is **€4,363,304** and the NPV value for three years is **-€596,587** and the IRR is **9.35%.** Over a three-year period, this case generates **€33,300,741** in gross revenue and **€5,207,413** in net income**.**

There is a separate non-rail round trip by truck and the truck segment from Forst-Wroclaw-Forst is priced at 1.2 X the rail rate and integrated into the revenues and costs. The base case scenario with the breakeven points for both trailers (loading units) and revenue are illustrated below in **Figure 23**.

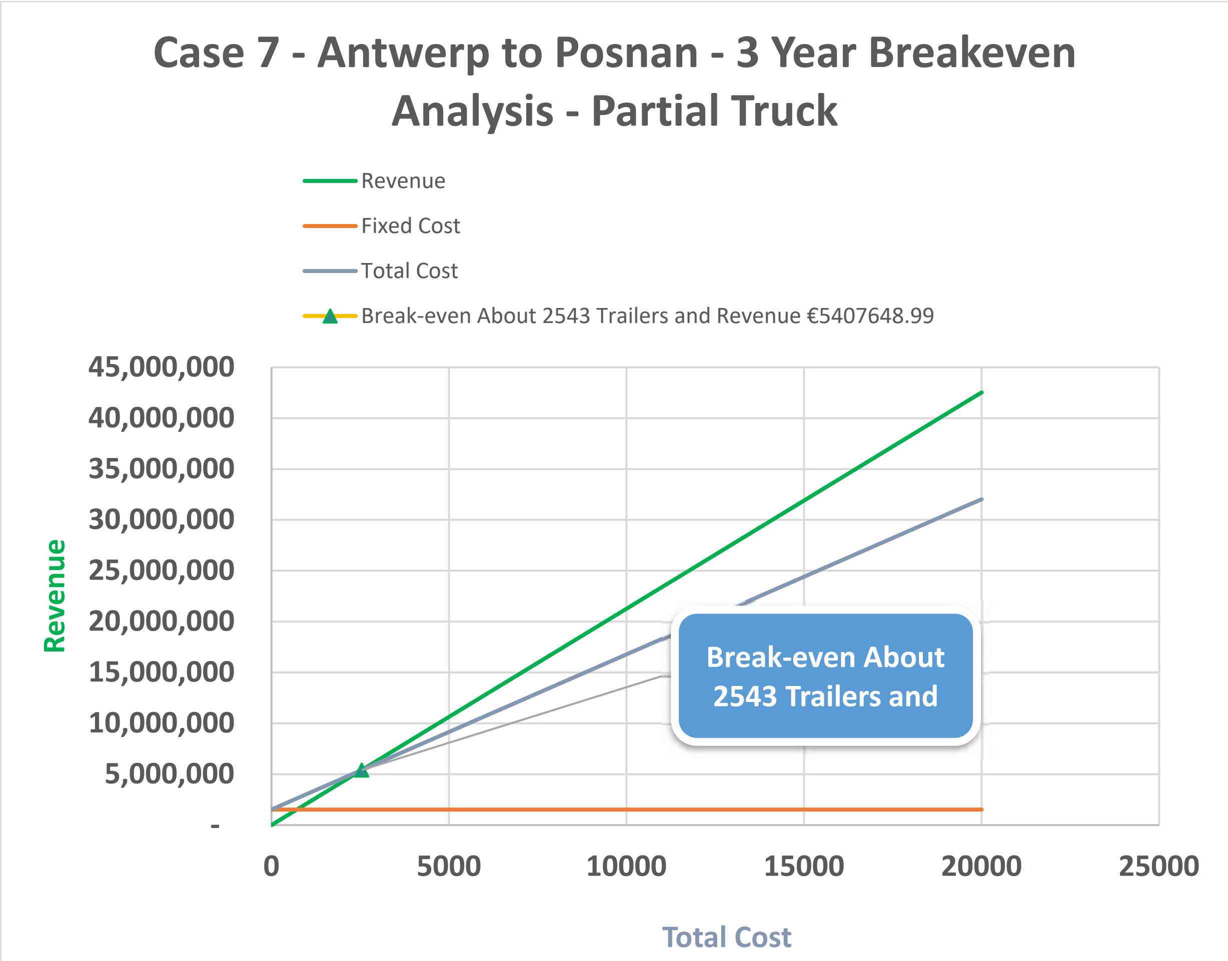


Figure 23: Breakeven Analysis - Case 7, Years 1 – 3

For Case 7, an overview of the NPV and IRR generated through the range of rates per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Wagons	With Truck Costs and Revenue Applied		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	**70.00%**	-€ 2,698,989.94	-14.37%
€ 1.20	**80.00%**	-€ 920,848.05	8.00%
€ 1.20	**90.00%**	**€ 1,450,007.80**	**32.45%**
€ 1.20	**100.00%**	**€ 3,228,149.68**	**48.44%**
€ 1.10	**70.00%**	-€ 3,884,417.86	-33.37%
€ 1.10	**80.00%**	-€ 2,254,454.47	-8.29%
€ 1.10	**90.00%**	-€ 81,169.94	17.18%
€ 1.10	**100.00%**	**€ 1,548,793.46**	**33.38%**
€ 1.00	**70.00%**	-€ 5,069,845.78	-63.89%
€ 1.00	**80.00%**	-€ 3,588,060.88	-28.11%
€ 1.00	**90.00%**	-€ 1,612,347.67	-0.14%
€ 1.00	**100.00%**	-€ 130,562.77	16.65%
€ 0.90	**70.00%**	-€ 6,697,518.18	N/A
€ 0.90	**80.00%**	-€ 4,921,667.29	-58.23%
€ 0.90	**90.00%**	-€ 3,143,525.41	-20.93%
€ 0.90	**100.00%**	-€ 1,809,918.99	-2.57%
€ 0.80	**70.00%**	-€ 8,545,664.68	N/A
€ 0.80	**80.00%**	-€ 6,697,518.18	N/A
€ 0.80	**90.00%**	-€ 4,674,703.14	-50.75%
€ 0.80	**100.00%**	-€ 3,489,275.22	-26.45%
€ 0.70	**70.00%**	-€ 10,393,811.19	N/A
€ 0.70	**80.00%**	-€ 8,776,683.00	N/A
€ 0.70	**90.00%**	-€ 6,620,512.08	N/A
€ 0.70	**100.00%**	-€ 5,168,631.44	-68.62%

Table 84: Case 7 Base Case Train Length Overview of NPV & IRR

The sensitivity analysis shows what combination of the variables could be profitable in Case 7.

17 Wagons	With Truck Costs and Revenue Applied		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	70.00%	€ 1,789,951.77	41.51%
€ 1.20	80.00%	€ 3,568,093.65	61.84%
€ 1.20	**90.00%**	**€ 5,938,949.50**	**85.80%**
€ 1.20	**100.00%**	**€ 7,717,091.39**	**101.99%**
€ 1.10	70.00%	€ 604,523.84	26.39%
€ 1.10	80.00%	€ 2,234,487.24	46.83%
€ 1.10	**90.00%**	**€ 4,407,771.77**	**70.69%**
€ 1.10	**100.00%**	**€ 6,037,735.16**	**86.74%**
€ 1.00	80.00%	€ 900,880.82	30.31%
€ 1.00	90.00%	€ 2,876,594.03	54.22%
€ 1.00	**100.00%**	**€ 4,358,378.93**	**70.18%**
€ 0.90	100.00%	2679022.71	51.98%
€ 0.80	100.00%	€ 999,666.48	31.60%

Table 85: Sensitivity Table 17 Wagons - Case 7

Each of these scenarios are at the upper bounds of both rate and load factors, given the cost structure of the case.

16 Wagons	With Truck Costs and Revenue Applied		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	70.00%	€ 604,523.84	26.39%
€ 1.20	80.00%	€ 2,975,379.69	55.33%
€ 1.20	**90.00%**	€ 4,753,521.58	**74.21%**
€ 1.20	**100.00%**	**€ 6,531,663.46**	**91.35%**
€ 1.10	80.00%	€ 1,691,166.11	40.30%
€ 1.10	90.00%	€ 3,321,129.50	59.16%
€ 1.10	**100.00%**	**€ 4,951,092.90**	**76.19%**
€ 1.00	80.00%	€ 406,952.52	23.71%
€ 1.00	90.00%	€ 1,888,737.43	42.71%
€ 1.00	100.00%	€ 3,370,522.33	59.70%
€ 0.90	90.00%	€ 456,345.35	24.38%
€ 0.80	100.00%	€ 209,381.20	20.98%

Table 86: Sensitivity Table 16 Wagons - Case 7

Each of these scenarios are at the upper bounds of both rate and load factors, given the cost structure of the case. A 16-wagon train is a risky proposition, as ensuring 90 to 100% load factor, coupled with the top rate per kilometer in the range may be difficult to achieve.

15 Wagons	**With Truck Costs and Revenues Applied**		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	70.00%	€ 11,809.88	18.20%
€ 1.20	80.00%	€ 1,789,951.77	41.51%
€ 1.20	90.00%	€ 3,568,093.65	61.84%
€ 1.20	**100.00%**	**€ 5,346,235.54**	**80.09%**
€ 1.10	80.00%	€ 604,523.84	26.39%
€ 1.10	90.00%	€ 2,234,487.24	46.83%
€ 1.10	**100.00%**	**€ 3,864,450.63**	**65.01%**
€ 1.00	90.00%	€ 900,880.82	30.31%
€ 1.00	100.00%	€ 2,382,665.73	48.56%
€ 0.90	100.00%	€ 900,880.82	30.31%

Table 87: Sensitivity Table 15 Wagons - Case 7

The same is true for the 15-wagon scenario, as the profitable combination of factors is at the upper range limits of rate per kilometer and load factor. These scenarios are less likely.

14 Wagons	**With Truck Costs and Revenues Applied**		
Rate	**Load Factor**	**NPV**	**IRR**
€ 1.20	80.00%	€ 604,523.84	26.39%
€ 1.20	90.00%	€ 2,382,665.73	48.56%
€ 1.20	**100.00%**	**€ 4,160,807.61**	**68.13%**
€ 1.10	90.00%	€ 1,147,844.98	33.50%
€ 1.10	**100.00%**	**€ 2,777,808.37**	**53.10%**
€ 0.90	100.00%	€ 11,809.88	18.20%

Table 88: Sensitivity Table 14 Wagons - Case 7

The window of profitability is very small with a train of only 14 wagons.

6.3.9 Case 8 – Rotterdam – (Forst) - Posnan

Case 8 rates sixth of the eight cases. As with Case 5, 6 and 7, Case 8 uses trucks for the short segment to/from Poland to/from the German border, because the Polish infrastructure authorities will not allow train lengths of more than 630 meters on their network, reducing the profitability of rail operations in Poland. This meant using trucks for the final segment to/from Poland. The initial capital to fund the enterprise is **€4,041,943** and the NPV value for three years is **-469,834** and the IRR is **10.68%.** Over three years, Case 8 generates a total of **€31,079,154** in gross revenue and net income generated is **€4,938,734**. The separate round trip and the truck segment from Forst-Wroclaw-Forst is priced at the same rate as rail X 1.2, as are the expenses for the route segment by truck.

The base case scenario with the breakeven points for both trailers (loading units) and revenue are illustrated below.

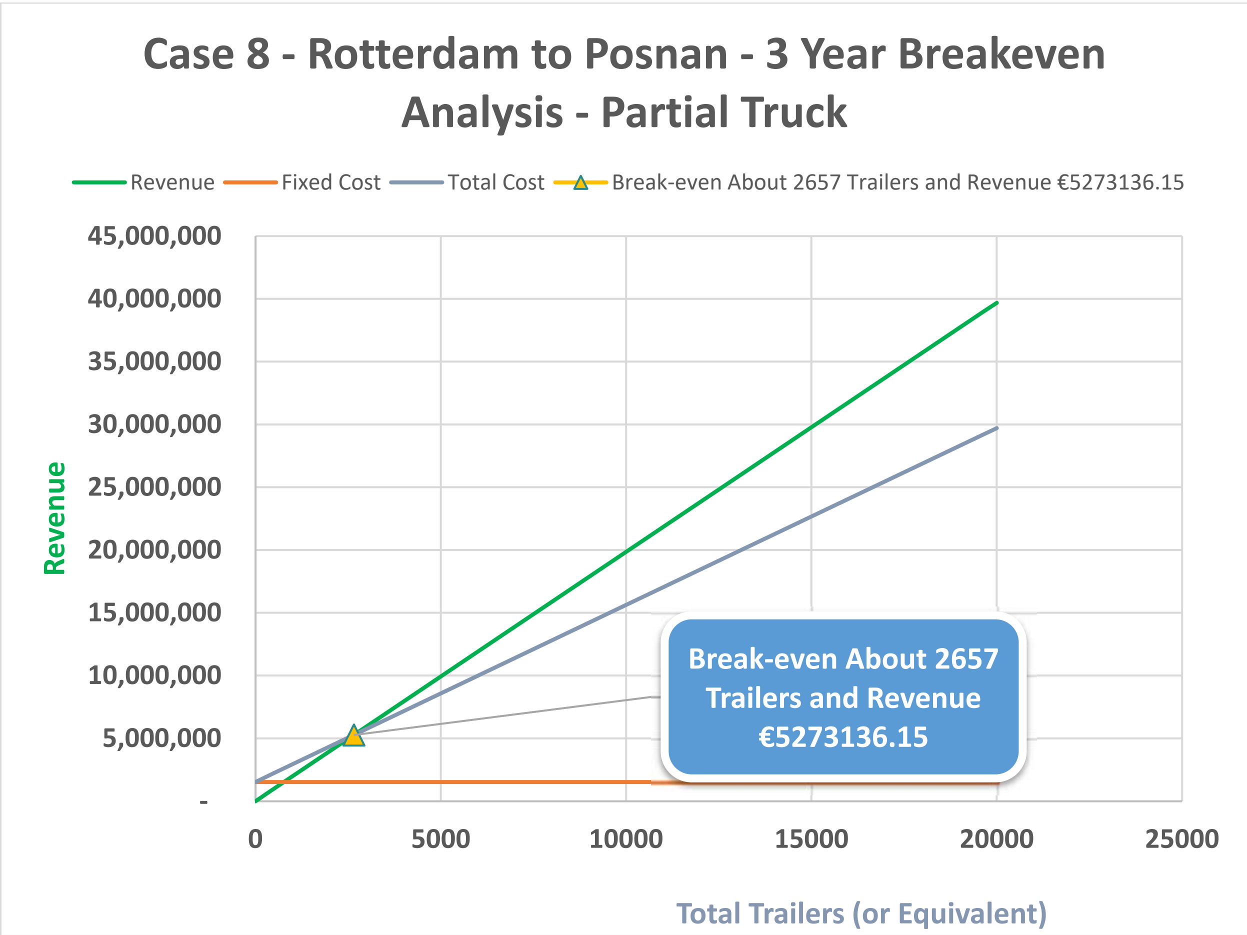


Figure 24: Breakeven Analysis - Case 8, Years 1 – 3

For Case 8, an overview of the NPV and IRR generated through the range of rates per km and load factors by a base case train length of 17 wagons is shown in the table below.

17 Wagons	With Truck Costs and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	70.00%	€ 1,720,378.34	42.36%
€ 1.20	80.00%	€ 3,309,675.06	61.82%
€ 1.20	90.00%	€ 5,428,737.34	84.69%
€ 1.20	100.00%	€ 7,018,034.06	100.09%
€ 1.10	70.00%	€ 660,847.20	27.88%
€ 1.10	80.00%	€ 2,117,702.52	47.45%
€ 1.10	90.00%	€ 4,060,176.28	70.27%
€ 1.10	100.00%	€ 5,517,031.60	85.58%
€ 1.00	70.00%	-€ 398,683.95	11.70%
€ 1.00	80.00%	€ 925,729.98	31.63%
€ 1.00	90.00%	€ 2,691,615.22	54.52%
€ 1.00	100.00%	€ 4,016,029.15	69.78%
€ 0.90	70.00%	-€ 1,458,215.09	-7.05%
€ 0.90	80.00%	-€ 266,242.55	13.84%
€ 0.90	90.00%	€ 1,323,054.16	37.09%
€ 0.90	100.00%	€ 2,515,026.70	52.38%
€ 0.80	70.00%	-€ 2,517,746.23	-30.80%
€ 0.80	80.00%	-€ 1,458,215.09	-7.05%
€ 0.80	90.00%	-€ 45,506.90	17.32%
€ 0.80	100.00%	€ 1,014,024.25	32.87%
€ 0.70	70.00%	-€ 3,586,498.67	N/A
€ 0.70	80.00%	-€ 2,650,187.63	-34.45%
€ 0.70	90.00%	-€ 1,414,067.96	-6.20%
€ 0.70	100.00%	-€ 486,978.21	10.26%

Table 89: Case 8 Base Case Train Length Overview of NPV & IRR

The sensitivity analysis shows what combination of the variables could be profitable in Case 8.

17 Wagons	With Truck Costs and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	70.00%	**€ 1,720,378.34**	**42.36%**
€ 1.20	**80.00%**	**€ 3,309,675.06**	**61.82%**
€ 1.20	**90.00%**	**€ 5,428,737.34**	**84.69%**
€ 1.20	**100.00%**	**€ 7,018,034.06**	**100.09%**
€ 1.10	70.00%	**€ 660,847.20**	**27.88%**
€ 1.10	**80.00%**	**€ 2,117,702.52**	**47.45%**
€ 1.10	**90.00%**	**€ 4,060,176.28**	**70.27%**
€ 1.10	**100.00%**	**€ 5,517,031.60**	**85.58%**
€ 1.00	80.00%	**€ 925,729.98**	**31.63%**
€ 1.00	**90.00%**	**€ 2,691,615.22**	**54.52%**
€ 1.00	**100.00%**	**€ 4,016,029.15**	**69.78%**
€ 0.90	90.00%	€ 1,323,054.16	37.09%
€ 0.90	**100.00%**	**€ 2,515,026.70**	**52.38%**
€ 0.80	100.00%	**€ 1,014,024.25**	**32.87%**

Table 90: Sensitivity Table 17 Wagons - Case 8

All the profitable scenarios for a train of 17 wagons are at the upper limits of rates per kilometer and load factors.

16 Wagons	With Truck Costs and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	70.00%	€ 660,847.20	27.88%
€ 1.20	**80.00%**	**€ 2,779,909.48**	**55.58%**
€ 1.20	**90.00%**	**€ 4,369,206.20**	**73.63%**
€ 1.20	**100.00%**	**€ 5,958,502.91**	**89.97%**
€ 1.10	**80.00%**	**€ 1,632,084.08**	**41.20%**
€ 1.10	**90.00%**	**€ 3,088,939.40**	**59.25%**
€ 1.10	**100.00%**	**€ 4,545,794.72**	**75.52%**
€ 1.00	80.00%	€ 484,258.67	25.32%
€ 1.00	**90.00%**	**€ 1,808,672.60**	**43.50%**
€ 1.00	**100.00%**	**€ 3,133,086.53**	**59.76%**
€ 0.90	90.00%	€ 528,405.80	25.96%
€ 0.90	**100.00%**	**€ 1,720,378.34**	**42.36%**
€ 0.80	100.00%	€ 307,670.15	22.71%

Table 91: Sensitivity Table 16 Wagons - Case 8

All the profitable scenarios for a train of 16 wagons are at the upper limits of rates per kilometer and load factors.

15 Wagons	With Truck Costs and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	70.00%	€ 131,081.63	20.04%
€ 1.20	80.00%	€ 1,720,378.34	42.36%
€ 1.20	90.00%	**€ 3,309,675.06**	**61.82%**
€ 1.20	**100.00%**	**€ 4,898,971.77**	**79.25%**
€ 1.10	90.00%	**€ 2,117,702.52**	**47.45%**
€ 1.10	**100.00%**	**€ 3,574,557.84**	**64.85%**
€ 1.00	90.00%	€ 925,729.98	31.63%
€ 1.00	100.00%	**€ 2,250,143.91**	**49.11%**
€ 0.90	100.00%	€ 925,729.98	31.63%

Table 92: Sensitivity Table 15 Wagons - Case 8

All the profitable scenarios for a train of 15 wagons are at the upper limit of load factor and/or rate per kilometer.

14 Wagons	With Truck Costs and Revenue Applied		
Rate	Load Factor	NPV	IRR
€ 1.20	80.00%	€ 660,847.20	27.88%
€ 1.20	90.00%	€ 2,250,143.91	49.11%
€ 1.20	**100.00%**	**€ 3,839,440.63**	**67.82%**
€ 1.10	90.00%	€ 1,146,465.64	34.69%
€ 1.10	**100.00%**	**€ 2,603,320.96**	**53.45%**
€ 1.00	90.00%	€ 42,787.36	18.69%
€ 0.90	100.00%	€ 131,081.63	20.04%

Table 93: Sensitivity Table 14 Wagons - Case 8

The single profitable scenario for a train of 14 wagons is at the upper limit of load factor and rate per kilometer.

6.4 Basic Formulas

The basic formulas underlying the analyses of the operational scenarios or "cases" were applied to each, individually, to determine costs, breakeven and profit scenarios.

6.4.1 Highest Cost Centers

To determine this, a matrix was generated in Excel to identify the highest cost categories in their respective orders, by case scenario, year and the overall three-year time series examined. The purpose of preparing this was to use it as a tool to focus on reducing the costs in the highest cost contributing categories, as well as to be able to "zoom out" to get a good perspective of the entire range of scenarios.

6.4.2 Break-even Point

The loading unit (trailer or container) breakeven points overall for each case were determined for the three-year timeline. The breakeven points can be seen on the graphs depicting the traffic for each case.

6.4.3 Profit Scenarios

The profit scenarios for each case scenario in each year, as well as over the three-year span of study were calculated and analyzed for realistic input ranges, as selected through the slide bar tools.

6.5 Applied Formulas

6.5.1 Breakeven for loading units (trailers or containers)

$$\boldsymbol{Breakeven\ in\ Loading\ Units\ (trailers)} = \frac{\boldsymbol{Fixed\ Costs}}{\boldsymbol{Revenue\ per\ Unit - Variable\ Costs\ per\ Unit}}$$

$$\boldsymbol{B_u = \frac{F_c}{R_u - V_c}}$$

Where:

Breakeven quantity of Units	B_u
Fixed costs	F_C
Revenue per Unit	R_u
Variable costs per Unit	V_C

Equation 5: Breakeven for Loading Units (trailers or containers)

6.5.2 Breakeven for Revenue

$$\textbf{Breakeven in Revenue} = \frac{\textbf{Fixed Costs} * \textbf{Revenue}}{\textbf{Revenue} - \textbf{Variable Costs}}$$

$$\boldsymbol{B}_{\boldsymbol{r}} = \frac{\boldsymbol{F_c} \times \boldsymbol{R_t}}{\boldsymbol{R_{t-V_c}}}$$

Where:

Breakeven revenue	B_r
Total Fixed costs	F_C
Total Revenue	R_t
Total Variable Costs	V_c

Equation 6: Breakeven for Revenue

6.5.3 Fixed Costs

Fixed cost = Loading units (Trailers or containers) * (Revenue – Variable Costs)

Equation 7: Breakeven for Fixed Costs

6.5.4 Contribution Margin

Contribution margin = (Revenue per Unit – Variable cost per Unit)

Each one of the above formulas is used in the costing model as a basis for the breakeven points on the case analysis charts.

6.6 Cost structure

6.6.1 General Proportion of Fixed to Variable Costs

In general, over all the case scenarios through all three years, including the total aggregate values over the entire three-year period, the consistent proportion of variable to fixed costs is approximately 88% and 12%, respectively, as shown in the following charts.

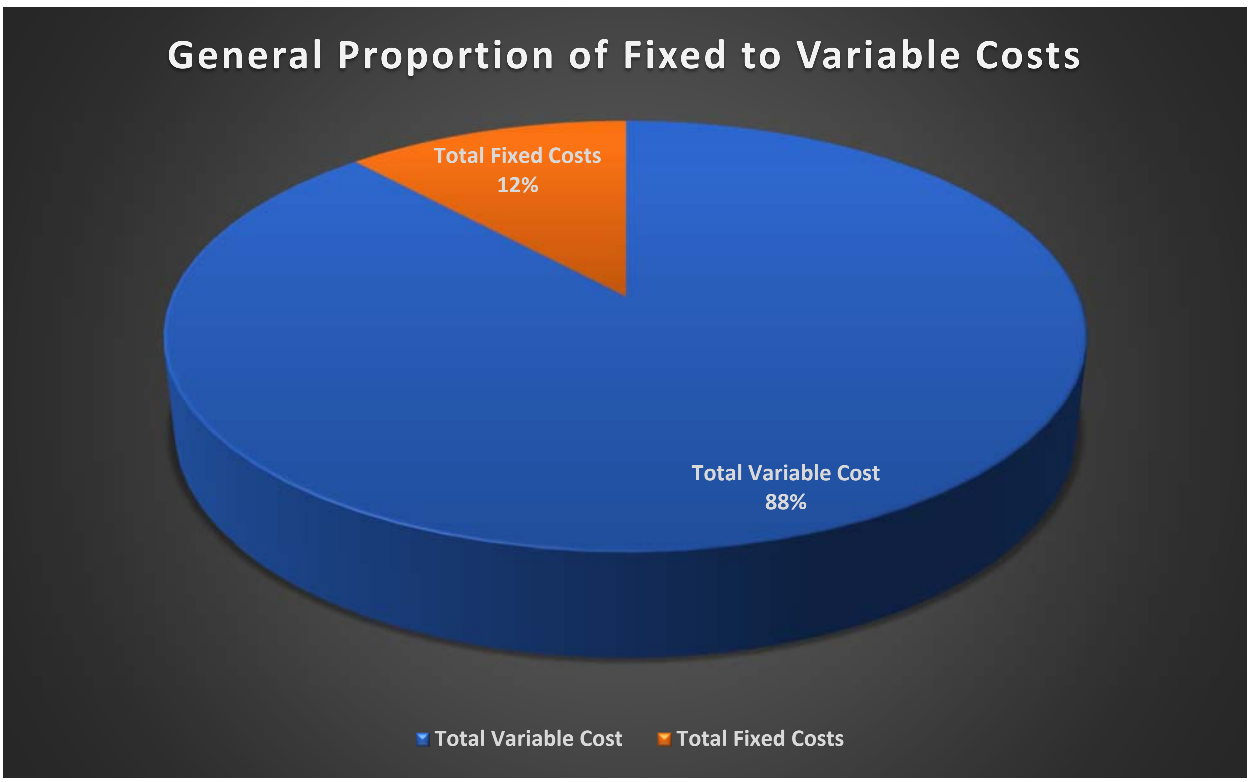


Figure 25: Fixed to Variable Cost Percentage

The fixed costs do not vary much, but the variable costs do vary substantially amongst the different case scenarios, as will be illustrated further.

For perspective, the graph in **Figure 25** illustrates the general variable cost proportional percentage used in the base Case 1 generic cost model.

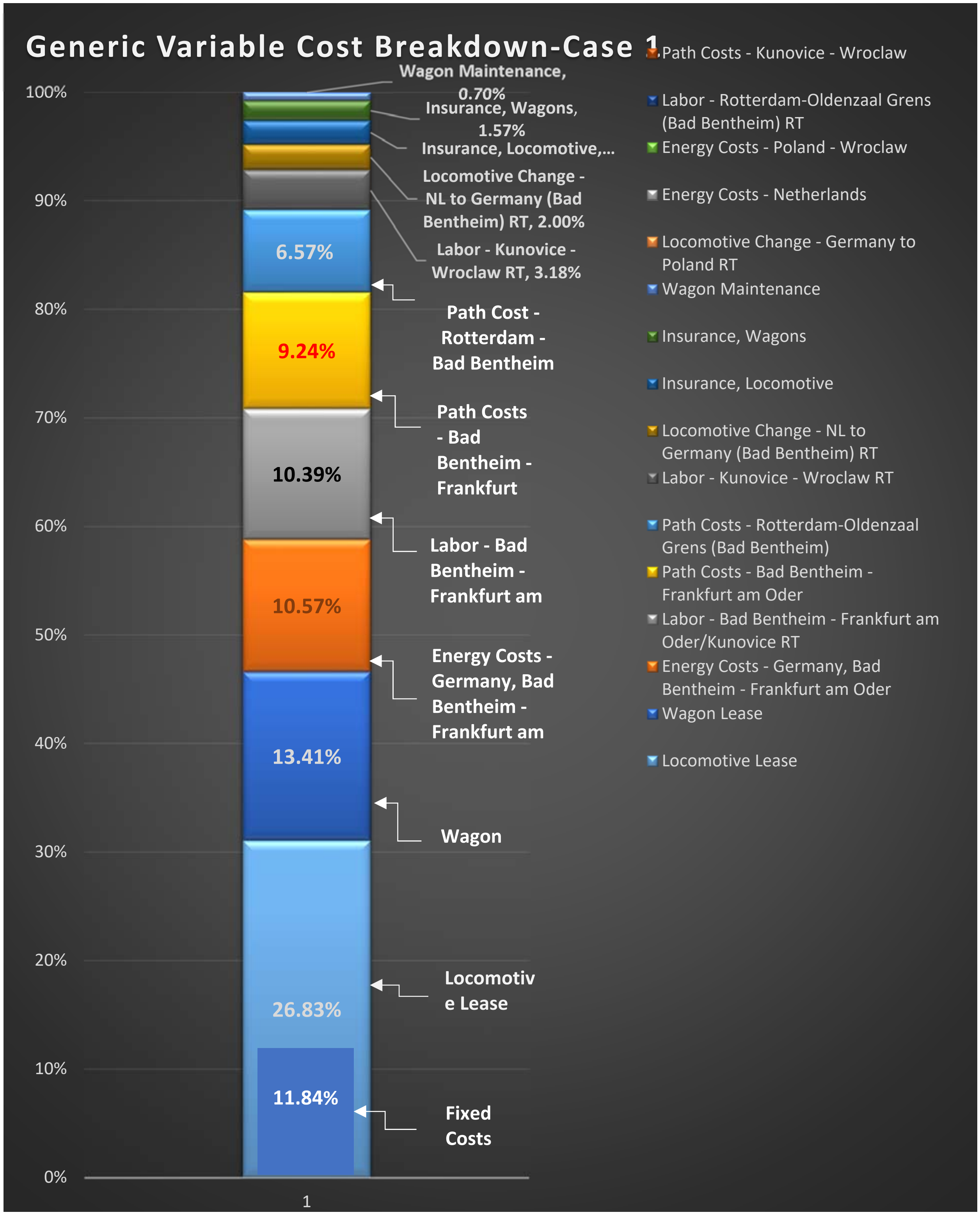


Figure 26: Generic Model Variable Cost Proportions

6.6.2 General Variable Costs in Rank Order

One of the main objectives of analyzing the variable costs is to identify what categories within which case scenario have the highest proportion of the costs. Identifying those specific costs is an important step in finding ways to reduce those costs to increase profitability.

6.6.2.1 Case 1 - Variable Costs in Rank Order

This scenario is for operations between Rotterdam and Wroclaw, routing through Bad Bentheim into Germany and through Frankfurt am Oder (Kunovice Poland), on the easternmost segment of the route.

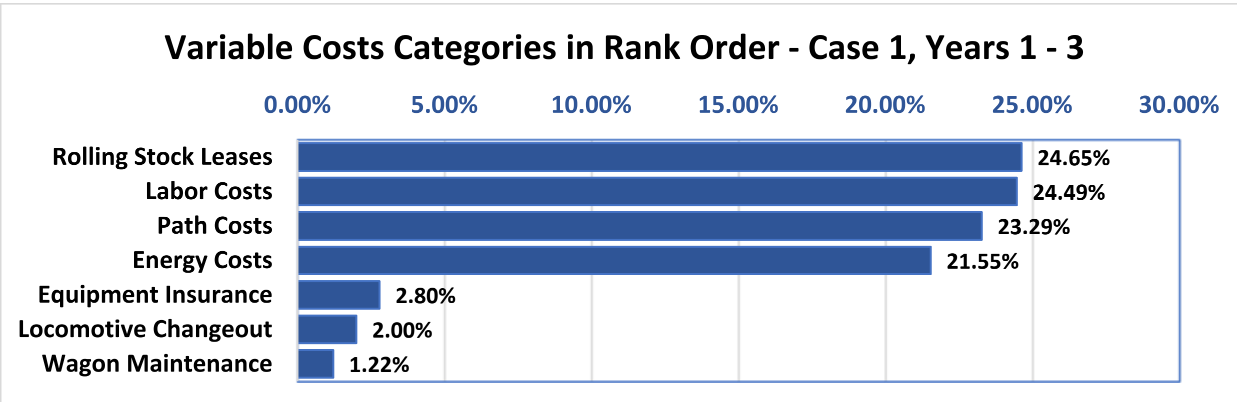


Figure 27: Variable Cost Categories, Case 1

The equipment leases are the most expensive cost components, and are variable, in the sense that, depending on the realized traffic level, it is possible to add or subtract wagons, as demand requires through spot leasing. If the traffic is steady and predictable, the costs then become relatively fixed. In general, the two equipment leases represent approximately 24.65% of the variable cost. The next largest cost categories are labor costs at 24.49%. Next are path costs and energy costs at 23.29% and 21.55% respectively, which are not controllable by management.

The insurance cost at 2.80% is similarly non-controllable, as it is based on the value of the equipment. Wagon maintenance at 1.22% and locomotive changeout at the German-Polish border are also not controllable by management, is 2.00%.

The data from the variable cost categories will be consolidated into an overall comparison of all the cases in **Chapter 7 – Conclusions** for a full perspective.

Figure 26 generically illustrates a more detailed breakdown of costs.

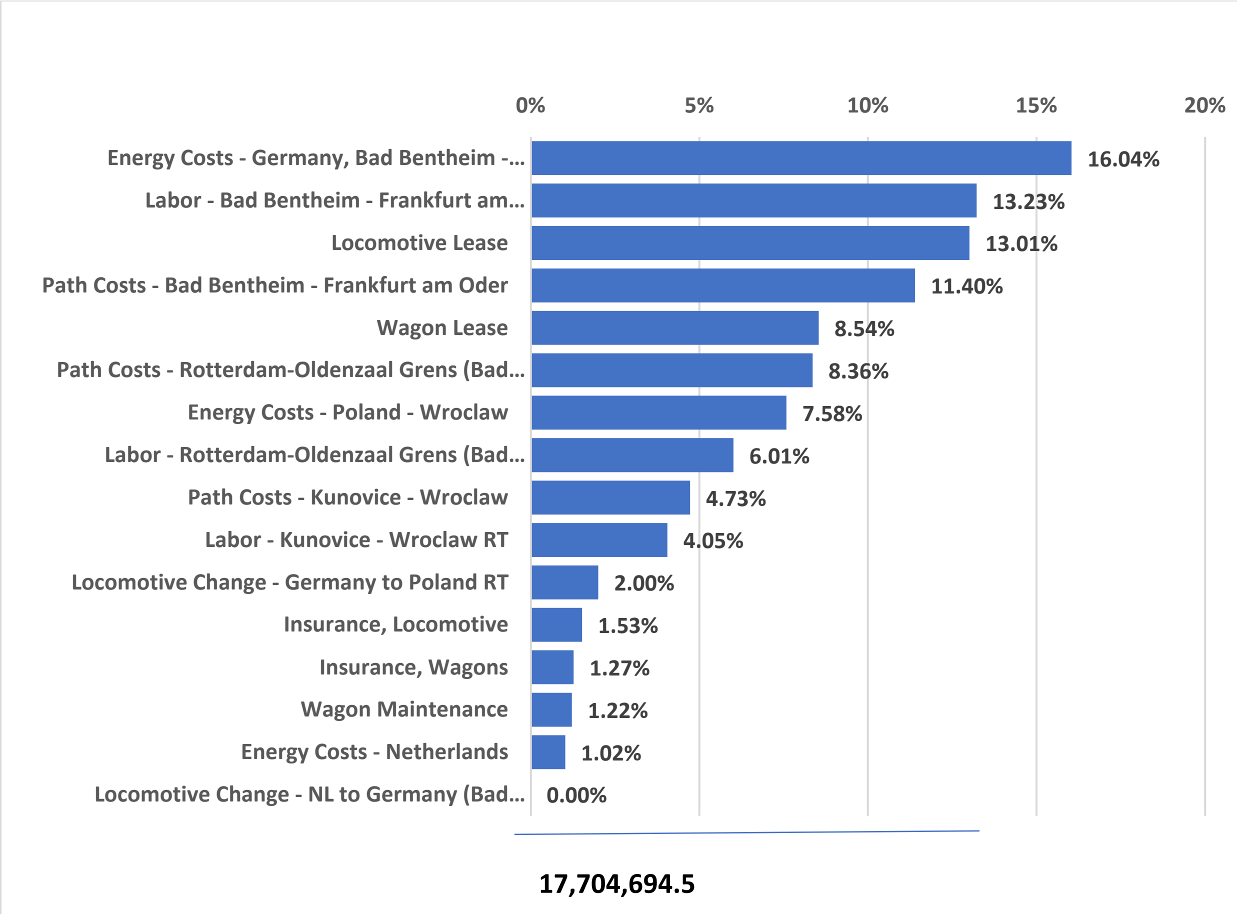


Figure 28: Detailed Cost Categories, Case 1

Individually, the next largest single cost categories are energy costs over the German trip segments (16.04%). labor costs for operating crews (23.29%) and path costs through Germany (11.40%) and path costs through the Netherlands to Rotterdam at 8.36%, which is high, relative to the path costs in Germany.

Though Poland has among the highest path costs in the EU, because the trip segment(s) from Kunovice to the six population centers in the Wroclaw metropolitan area are short (averaging approximately 238 km), the relative proportion of variable costs in low, at 4.73%.

Overall, the cost categories with the likeliest potential for reduction (ceteris paribus for train length), are locomotive lease costs, by using older electric locomotives with a lower capital cost, therefore lease cost, energy, by using electric vs. diesel electric locomotives and reduced path and energy costs by operating late nights, when path and energy demands are lower and the infrastructure rates reflect those off-peak hours.

As there are numerous combinations of paths through Germany, it is beyond the scope of this research to investigate all possible path combinations.

The total variable costs for Scenario Case 1 are €17,704,694.50, calculated through the costing model.

6.6.2.2 Case 2 - Variable Costs in Rank Order

This scenario is for operations between Antwerp and Wroclaw, routing through Aachen into Germany and through Frankfurt am Oder (Kunovic Poland), on the easternmost segment of the route to the six population centers in the Wroclaw metropolitan area.

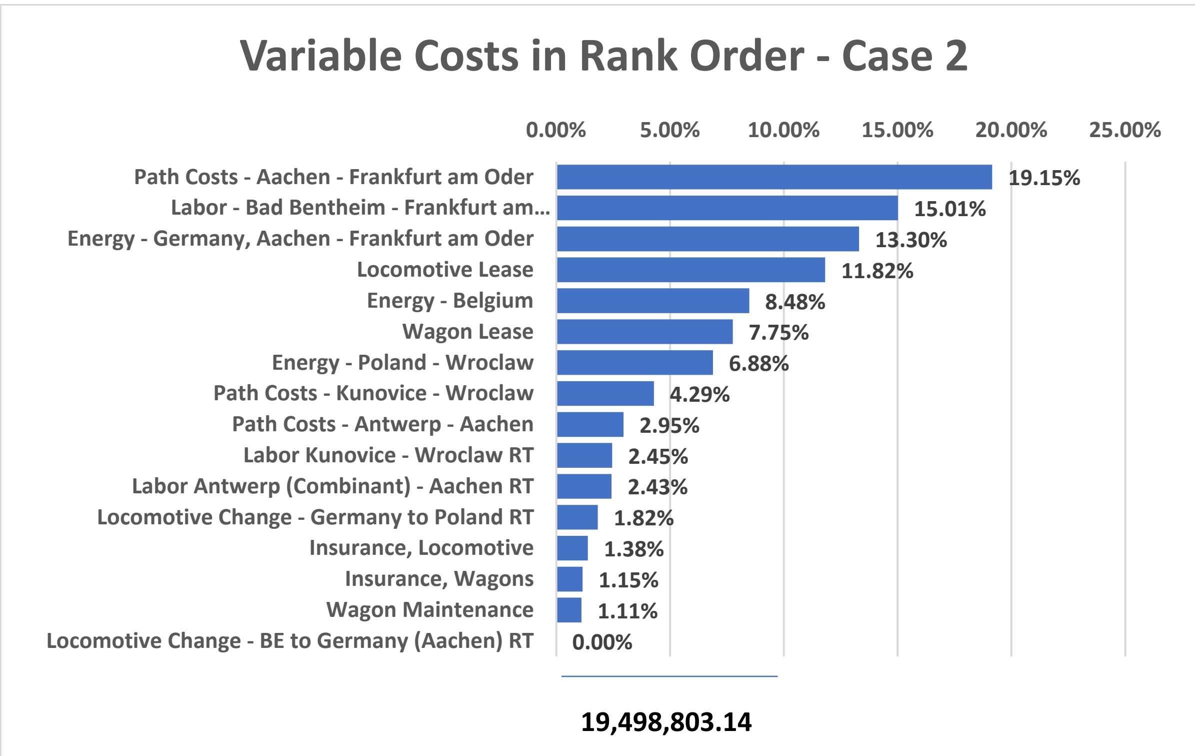


Figure 29: Variable Costs by Proportion, Case 2

The largest cost category is energy costs overall energy costs are 28.67%, of which the German trip segments are 13.30%. The energy costs have some potential for reduction, depending on what locomotives are available and the paths through Germany.

The second largest cost categories are paths, overall, at 26.40% and 19.15% within Germany. Poland has among the highest path costs in the EU, but because the trip segment(s) from Kunovice to the six population centers in the Wroclaw metropolitan area are short (averaging approximately 238 km), the relative proportion of variable costs in low, at 4.29%.

The third highest are labor costs for operating crews at 19.90%. The fourth category, the locomotive lease is 11.82% and wagons are 7.75% and are variable, through different categories of leases (spot, short or long term), and by varying the types of locomotives leased. The locomotives available at any given time can vary, as the equipment lease market is dynamic. depending on the level of traffic volume commitment from the customers. Depending on the realized traffic level, it is possible to add or subtract wagons, as demand requires, adapting the cost through different types of lease transactions. If the traffic is steady and predictable, the costs then become fixed. In general, the two equipment leases represent approximately 19.57% of the variable cost.

The cost categories having the most likely potential for reduction (ceteris paribus for train length), are locomotive lease costs, by using older electric locomotives with a lower capital cost, therefore lease cost, energy, by using electric vs. diesel electric locomotives and reduced path and energy costs by operating late nights, when path and energy demands are lower and the infrastructure rates reflect off-peak hour pricing. As there are numerous combinations of paths through Germany, it is beyond the scope of this research to investigate all possible path combinations.

The total variable costs for Scenario Case 2 are €19,498,802.14, (with an extra $1 added for graph aesthetics purposes).

Overall, the cost categories for Case 2 are consolidated into **Figure 30**.

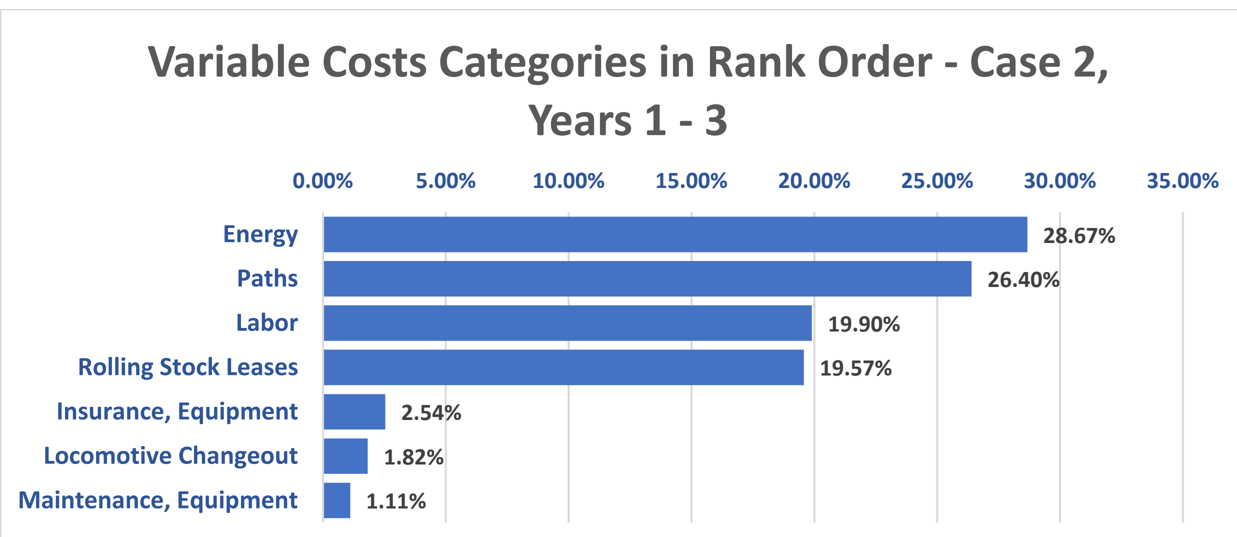


Figure 30: Variable Cost Categories, Case 2

6.6.2.3 Case 3 - Variable Costs in Rank Order

This scenario is for operations between Rotterdam and Posnan, routing through Bad Bentheim into Germany and through Frankfurt am Oder (Kunovic Poland), on the easternmost segment of the route.

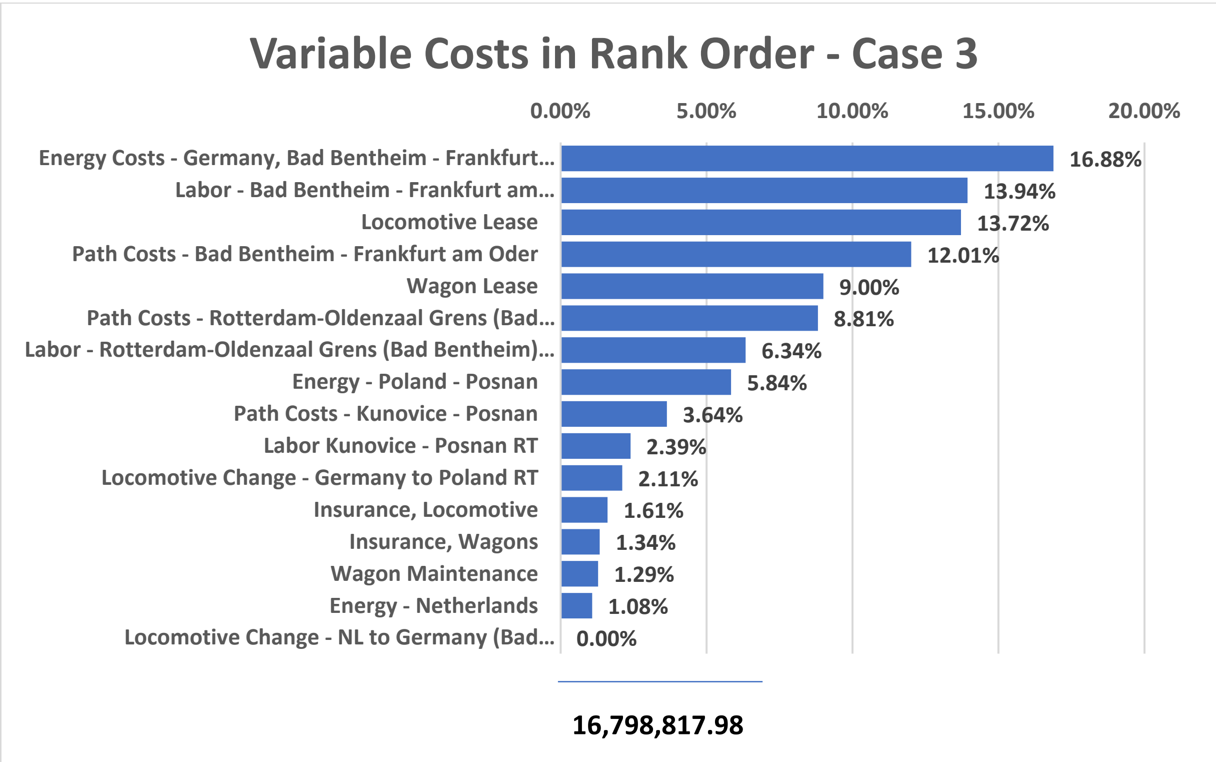


Figure 31: Variable Costs by Proportion, Case 3

In case 3, the highest cost categories are paths, labor and energy and then equipment leases.

Individually, the path, labor and energy costs across Germany are the highest 12.01%, 13.94% and 16.88% respectively. This makes sense, as the German trip segment is the longest. Path costs through Netherlands to Rotterdam are disproportionately high at 8.81%.

Though Poland has among the highest path costs in the EU, because the trip segment(s) from Kunovice to the four population centers in the Posnan metropolitan area are short (averaging approximately 174 km), the relative proportion of variable costs in low, at 3.64%, though energy costs are high at 5.84% of the total variable costs.

The cost categories having the most likely potential for reduction (ceteris paribus for train length), are locomotive lease costs, by using older electric locomotives with a lower capital cost, therefore lease cost, energy, by using electric vs. diesel electric locomotives and reduced path and energy costs by operating late nights, when path and energy demands are lower and the infrastructure rates reflect those off-peak hours. As there are numerous combinations of paths through Germany, it is beyond the scope of this research to investigate all possible path combinations.

In summary, path costs represent the highest cost category at 31.24% overall, due to the disproportionately higher costs in the Netherlands and Poland. Labor is the second highest cost category at 23.29% overall, followed closely by energy at 20.90%

Overall, the two equipment leases represent approximately 18.71% of the variable cost.

The total variable costs for Scenario Case 3 are €16,798,817.98.

The cost categories for Case 3 are consolidated into **Figure 32** below.

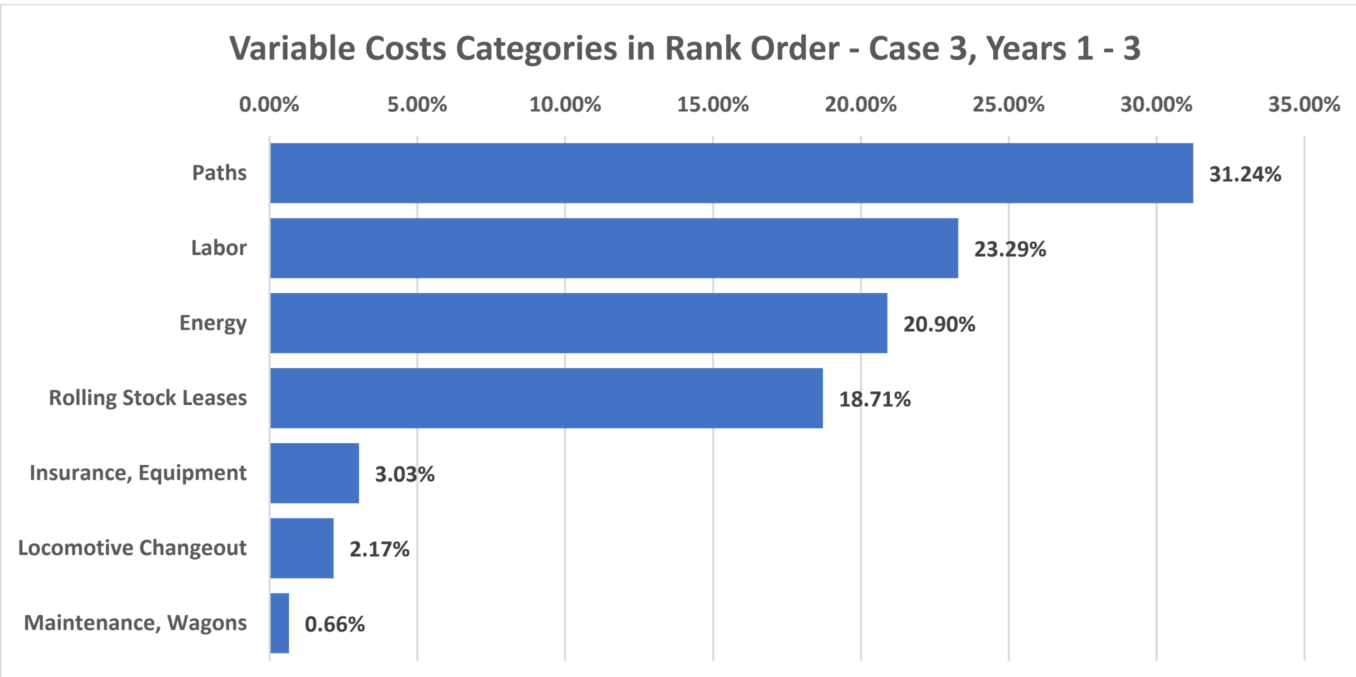


Figure 32: Variable Cost Categories, Case 3

6.6.2.4 Case 4 - Variable Costs in Rank Order

This scenario is for operational case between Antwerp and Posnan, routing through Aachen into Germany and through Frankfurt am Oder (Kunovic Poland), on the easternmost segment of the route.

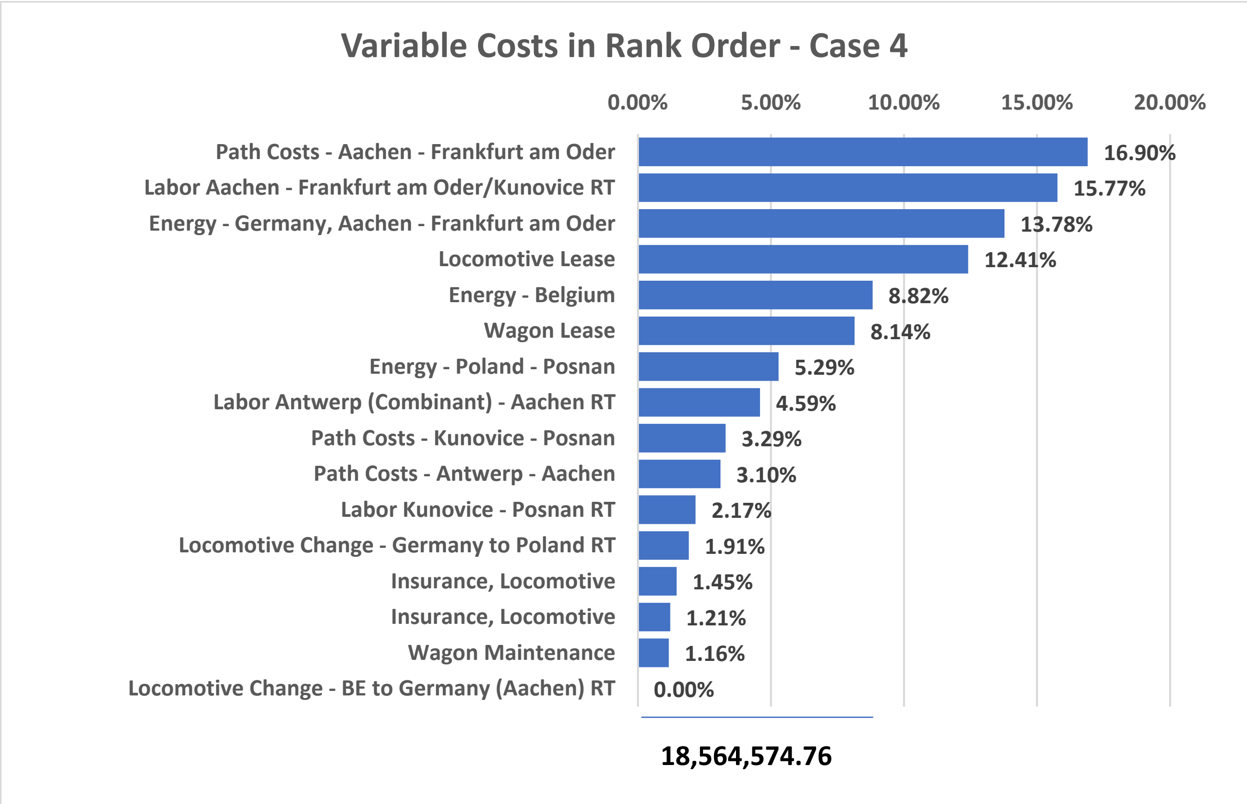


Figure 33: Variable Costs by Proportion, Case 4

In case 4, the highest cost categories are energy, paths and labor and then equipment leases.

Individually, the path, labor and energy costs across Germany are the highest 16.90%, 15.77% and 30.74% respectively. This makes sense, as the German trip segment is the longest. Path costs through Belgium to Antwerp are not as high as in the Netherlands to Rotterdam, at 8.81%. The path costs to Antwerp from the border at Aachen represent 3.10%, in comparison.

The energy costs have some potential for reduction, depending on what locomotives are available and the paths through Germany.

Though Poland has among the highest path costs in the EU, because the trip segment(s) from Kunovice to the four population centers in the Posnan metropolitan area are short (averaging approximately 174 km), the relative proportion of variable costs in low, at 3.29%.

The locomotive lease ranks lower as an individual cost component at 12.41% and is variable, through different categories of leases (spot, short or long term), and by varying the types of locomotives leased. The locomotives available at any given time can vary, as the equipment lease market is dynamic. Wagon lease expenses are like Case 3, at 8.14% vs. 9.00% in case 3.

Wagon leases are also variable, through different categories of leases (spot, short or long term), contingent on the level of traffic volume commitment from the customers. Depending on the realized traffic level, it is possible to add or subtract wagons, as demand requires, adapting the cost through different types of lease transactions. If the traffic is steady and predictable, the costs then become relatively fixed. The two equipment leases represent 18.71% of the variable cost.

The cost categories having the most likely potential for reduction (ceteris paribus for train length), are locomotive lease costs, by using older electric locomotives with a lower capital cost, therefore lease cost, energy, by using electric vs. diesel electric locomotives and reduced path and energy costs by operating late nights, when path and energy demands are lower and the infrastructure rates reflect those off-peak hours.

The total variable costs for Scenario Case 4 are €18,564,574.76. **Figure 34** compares overall cost categories in Case 4.

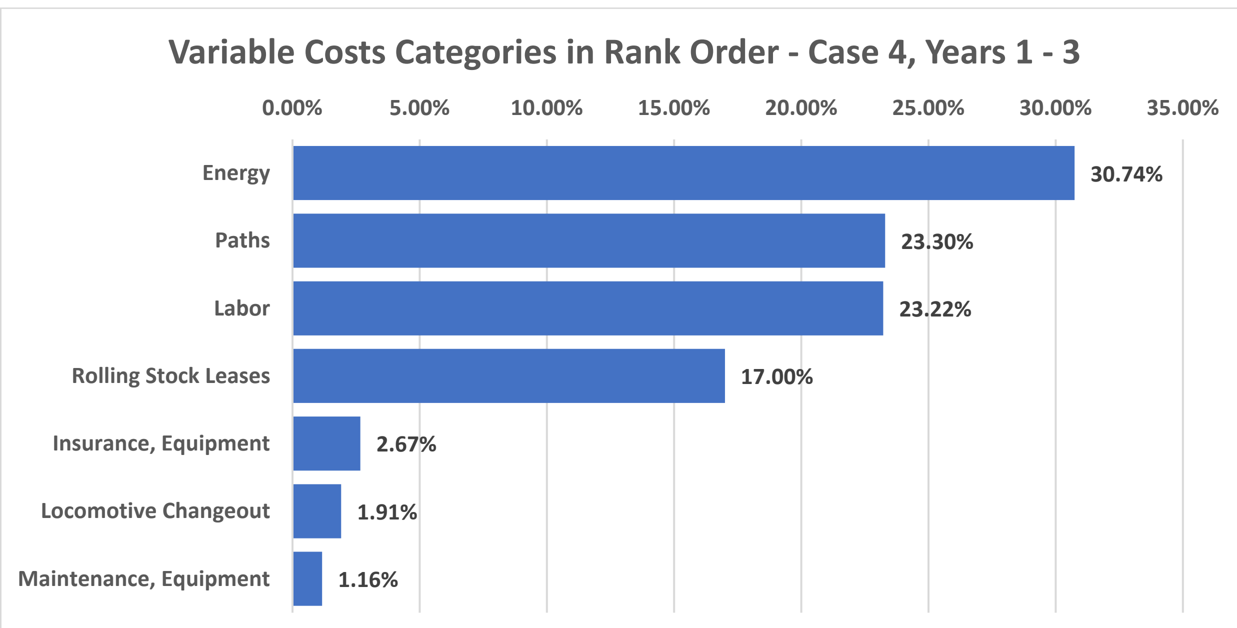


Figure 34: Variable Cost Categories, Case 4

6.6.2.5 Case 5 - Variable Costs in Rank Order

This scenario is for operations between Rotterdam and Wroclaw, routing through Bad Bentheim into Germany and into Wroclaw, However, the modeling of this and the next three scenarios will be different into Poland by routing through an intermodal terminal in Forst Germany and then shifting the trailers to truck for the remaining average of 274 km to the six municipalities of the Wroclaw metropolitan area. The motivation for this scenario is the general restriction on train lengths allowed by Poland, resulting in less wagons and trailers per train. The short train length diminishes the scale advantage of rail, leading to the investigation as to whether greater profit could be realized by experimenting with that combination of modes vs. remaining with rail over all the trip segments.

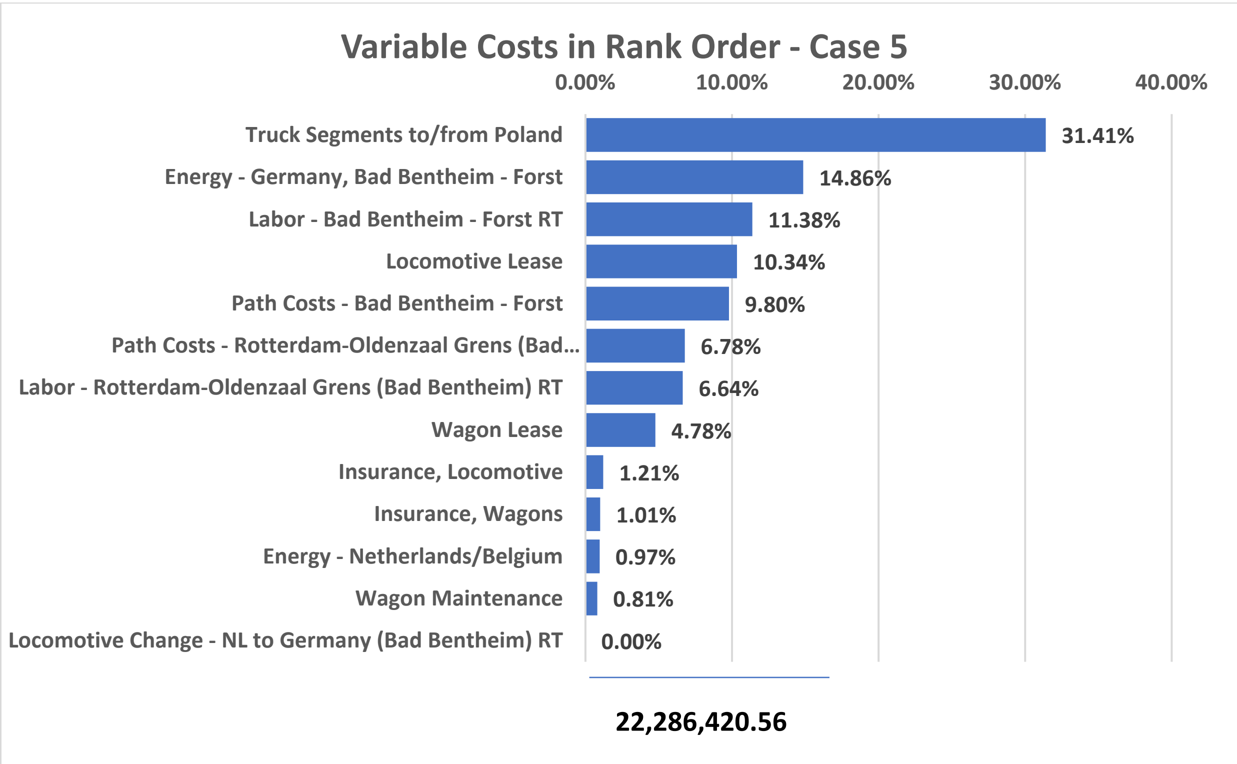


Figure 35: Variable Costs by Proportion, Case 5

The highest cost category is for the truck costs from Forst to the six municipalities of the Wroclaw metropolitan area. Under this scenario, the segments operated by truck in Poland are the highest cost category at 31.41%. The truck revenue and costs are assumed to approximate each other by referencing the *Ti* Upply data for truck rates between the territories served in Germany and Poland.

The operating crew labor represents approximately 18.03% labor, the second highest. The third highest costs are for paths at 16.58% overall of costs. The fourth highest cost category are the energy costs over the German trip segments (14.86%), and 15.83% overall. The energy costs have some potential for reduction, depending on what locomotives are available, as well as the paths through Germany, but in this case, diesel electric locomotives must be used, due to portions of the DB route to Forst that are not electrified.

Locomotive leases are 10.34% of costs and the wagon leases are 4.78% of costs. The wagon leases are variable, through different categories of leases (spot, short or long term), depending on the level of traffic volume commitment from the customers. Depending on the realized traffic level, it is possible to add or subtract wagons, as demand requires, adapting the cost through different types of lease transactions. If the traffic is steady and predictable, the costs then become relatively fixed. The two equipment leases represent approximately 15.12% of the variable cost.

The cost categories having the most likely potential for reduction (ceteris paribus for train length – longer in length here), are locomotive lease costs, by using older diesel locomotives with a lower capital cost, therefore lower lease cost. There will not be much energy savings, in this case, by using electric vs. diesel locomotives, because the path to Forst is not electrified. It may be possible to achieve reduced path costs by operating late nights, when path capacity demands are lower and the infrastructure rates reflect those off-peak hours. As there are numerous combinations of paths through Germany, it is beyond the scope of this research to investigate all possible path combinations.

The main target for cost reduction is trucking costs, specifically, by eliminating them completely. Unfortunately, this is a variable cost category that cannot be controlled by management and would have to be remedied by some form of reform of infrastructure regulations in Poland and/or adding railway infrastructure by increasing the length of passing sidings and yard track length.

The total variable costs for Scenario Case 5 are €22,286,421.

A summary of variable costs is in **Figure 36**.

Figure 36: Variable Cost Categories, Case 5

6.6.2.6 Case 6 - Variable Costs in Rank Order

This scenario is for operations between Antwerp and Wroclaw, routing through Aachen into Germany and into Wroclaw, However, the modeling of this and scenario cases 5, 7 and 8 will be different into Poland by routing through an intermodal terminal in Forst Germany and then shifting the trailers to truck for the remaining average of 274 km to the six municipalities of the Wroclaw metropolitan area. The motivation for this scenario is the general restriction on train lengths allowed by Poland, resulting in less wagons and trailers per train. The short train length diminishes the scale advantage of rail, leading to the investigation as to whether greater profit could be realized by experimenting with that combination of modes vs. remaining with rail over all the trip segments.

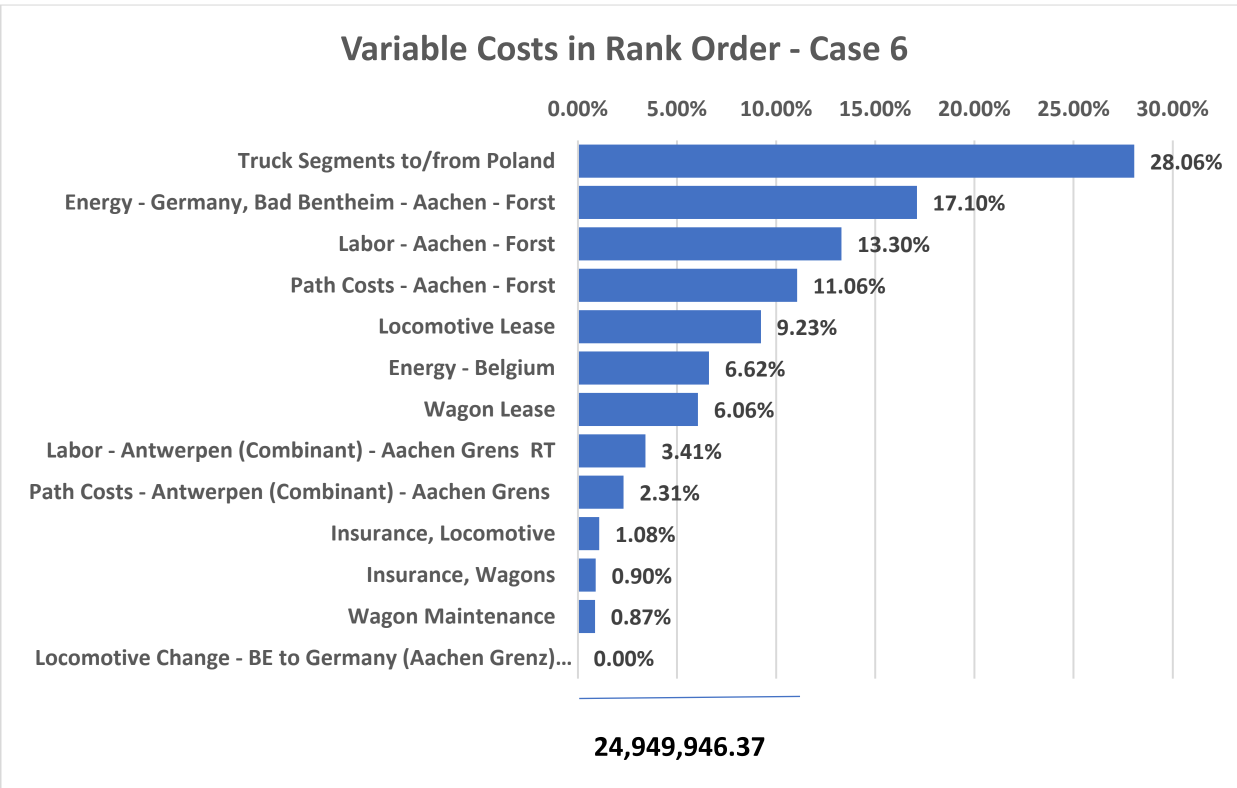


Figure 37: Variable Costs Detail, Case 6

The highest cost category is for the truck costs from Forst to the six municipalities of the Wroclaw metropolitan area. Under this scenario, the segments operated by truck in Poland are the highest cost category at 28.06%. Truck revenue and costs are assumed to approximate each other, using the *Ti* Upply data for truck rates between the territories served in Germany and Poland. More on this topic can be found in the detail of the sensitivity analysis in **Appendix F – Sensitivity Analysis – Road Freight Rates.**

As mentioned in the narrative for Case 5, the largest influencer of incurring these costs are the Polish infrastructure limitations and regulations. When those issues are remedied, the trucking costs are eliminated.

The second largest cost category are the energy costs over the German trip segments (17.10%). The energy costs have some potential for reduction, what locomotives that are homologated for all three countries are available and the paths through Germany, but in this case, diesel locomotives must be used, due to portions of the DB route to/from Forst not being electrified.

Labor is the third largest cost category, with 13.30% for the German segment and 3.41% for the Belgian segment. Combined, labor represents 16.71% of the variable costs.

Path costs over the German route segment represents the fourth largest cost category at 11.06% and combined with the Belgian route segment labor at 2.31%, the total path cost category is 13.37%.

The total variable costs for Scenario Case 6 are €24,949,946.37.

A summary of variable cost categories is shown in **Figure 38**, below.

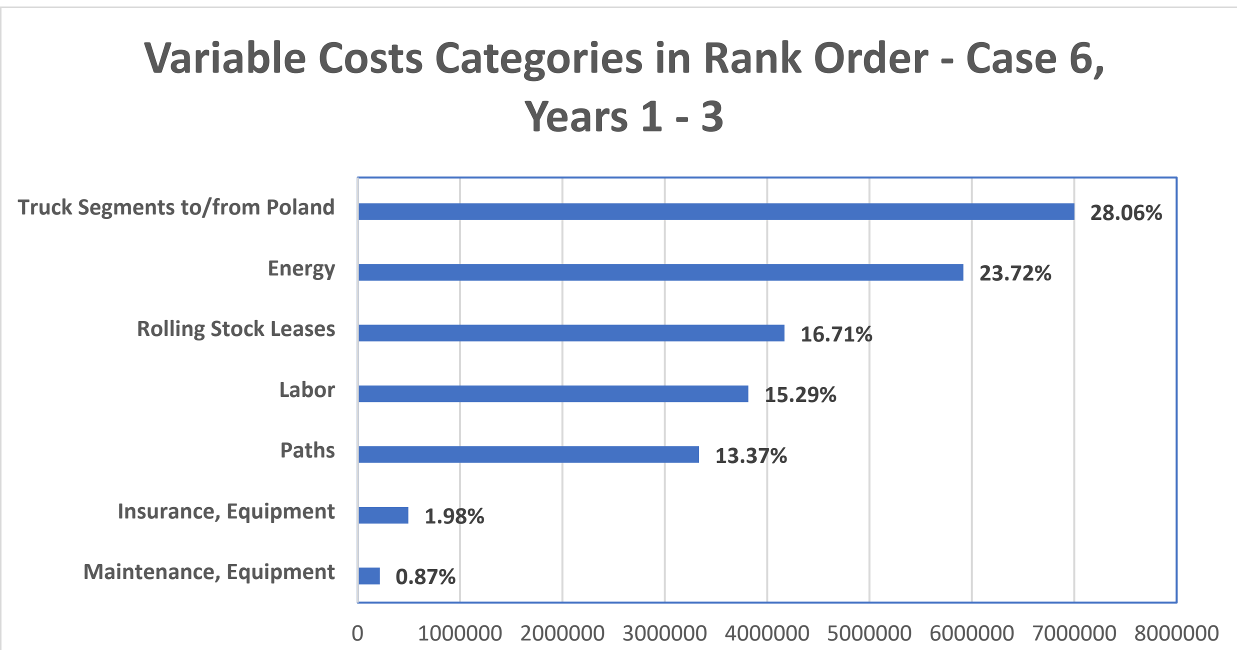


Figure 38: Variable Cost Category Summary, Case 6

6.6.2.7 Case 7 - Variable Costs in Rank Order

This scenario is for operations between Antwerp and Posnan, routing through Aachen into Germany and into Posnan, However, the modeling of this and scenario cases 5, 6 and 8 will be different into Poland by routing through an intermodal terminal in Forst Germany and then shifting the trailers to truck for the remaining average of 174 km to the four municipalities of the Posnan metropolitan area. The motivation for this scenario is the general restriction on train lengths allowed by Poland, resulting in less wagons and trailers per train. The short train length diminishes the scale advantage of rail, leading to the investigation as to whether greater profit could be realized by experimenting with that combination of modes vs. remaining with rail over all the trip segments.

As with Cases 5 and 6, truck operated segments from Forst to the four municipalities of the Posnan metropolitan area. Those costs represent the highest cost category at 25.13% due to the operating costs estimated to equal revenues.

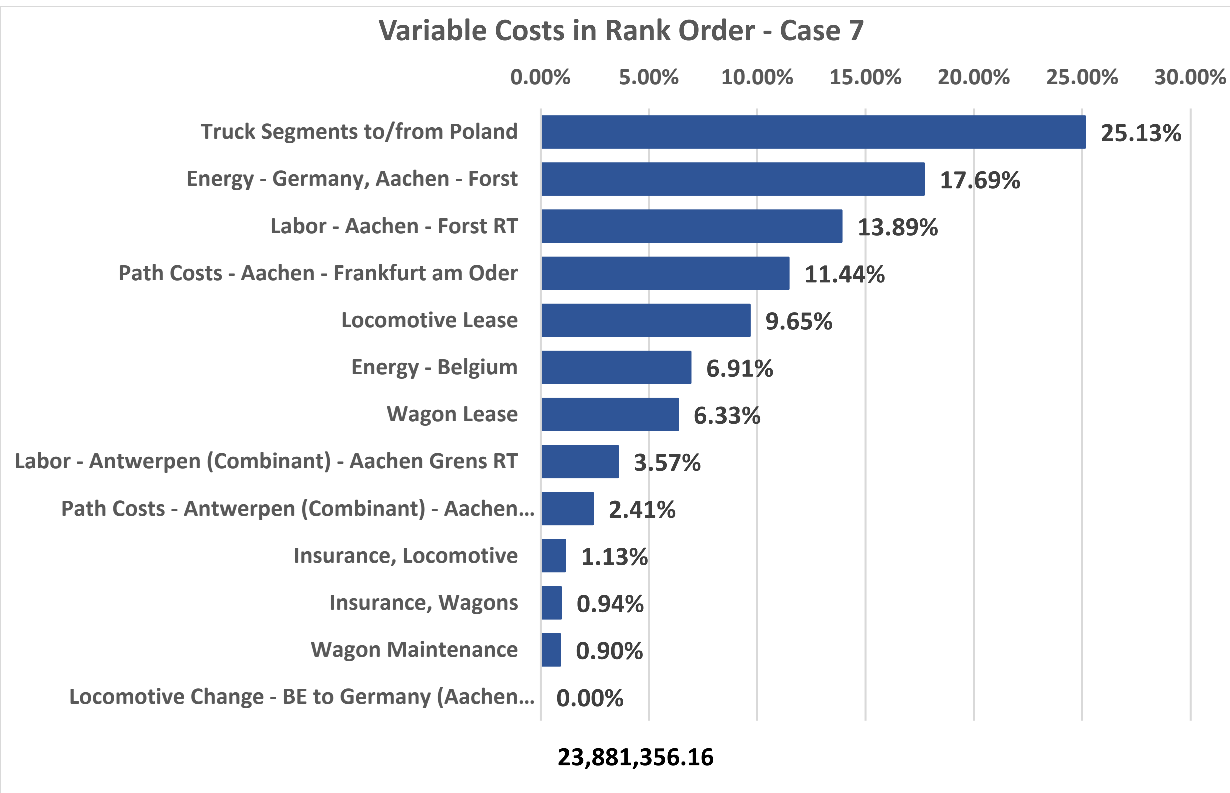


Figure 39: Variable Cost Detail, Case 7

The second largest cost category are the energy costs over the German trip segments (17.69%). The energy costs have some potential for reduction, depending on what locomotives are available and the paths through Germany, but in this case, diesel electric locomotives must be used, due to portions of the DB route to Forst not being electrified. For cost reduction, that leaves only selecting path availability at off-peak hours, which will have different energy consumption profiles.

Compared to the equivalent trip in Case 4, energy costs in Germany are 13.77% vs. 17.69% in Case 7. However, energy costs in Belgium are higher in Case 4 using electric locomotives at 8.82% vs. 6.91% in Case 7 using diesel locomotives. This is because the routing in Belgium is more circuitous with electric vs. diesel locomotives. The combined energy costs are 27.88% for Case 4 vs. 24.61% in Case 7.

The third highest cost category are for labor operating costs in Germany, accounting for 13.89% and labor costs operating in Belgium, at 3.57%. The combined labor total is 17.46%. Comparing labor costs in Case 4 at 22.52% vs. 17.46% for Case 7, it is easy to see the difference is in not operating the path segment in Poland. The opportunities for labor cost reduction, however, are limited and related to elapsed time over the available paths at any given time.

Path costs represent the fourth highest cost category at 11.44% for Germany and 2.41% for Belgium, with a combined total of 13.85%. Compared to the equivalent Case 4, the combined total path costs are 23.30%, so, Case 7 is 11.51% and Case 4 is 23.30%. This is equally obvious, as the path segment through Poland is not being operated over rail. Comparing total operating costs for Case 4, €18,564,574.76 vs. Case 7, €23,881,356.16, the difference is mainly because of the trucking cost over the final trip segment to/from Forst Germany and Posnan Poland. A summary of variable cost categories is shown in **Figure 40**, below.

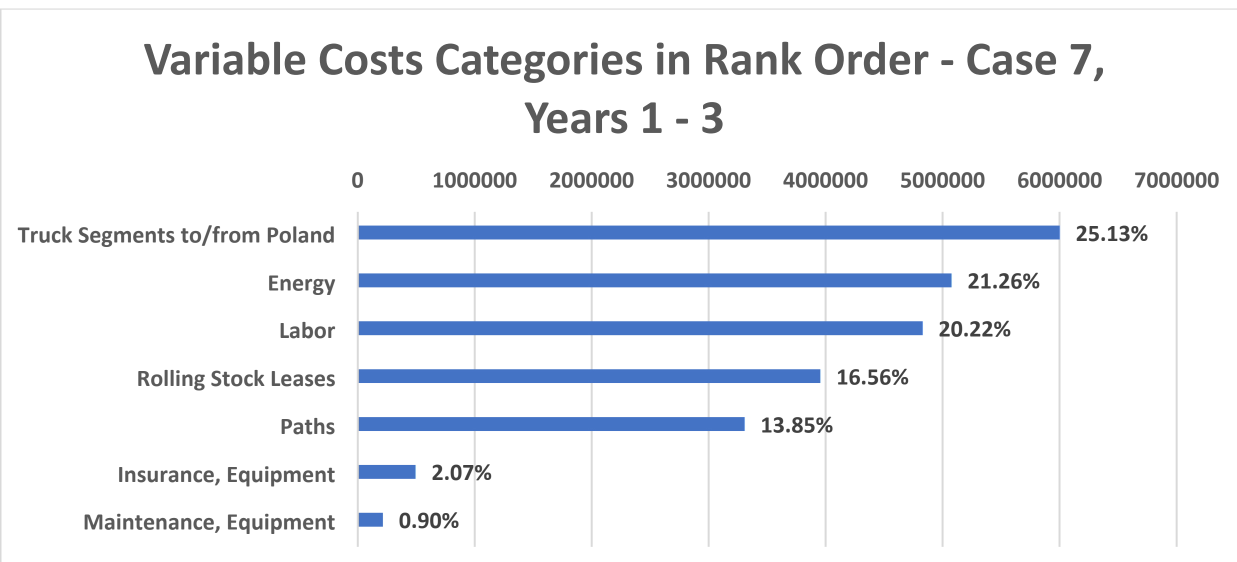


Figure 40: Variable Cost Category Summary - Case 7

6.6.2.8 Case 8 - Variable Costs in Rank Order

This scenario is for operations between Rotterdam and Posnan, routing through Bad Bentheim into Germany and into Posnan, However, the modeling of this case and scenario Cases 5, 6 and 7 will be different into Poland by routing through an intermodal terminal in Forst Germany and then shifting the loading units to truck for the remaining average of 174 km to the four municipalities of the Posnan metropolitan area. The motivation for this scenario is the general restriction on train lengths allowed by Poland, resulting in less wagons and trailers per train. The short train length diminishes the scale advantage of rail, leading to the investigation as to whether greater profit could be realized by experimenting with that combination of modes vs. remaining with rail over all the trip segments.

As with Cases 5, 6 and 7, truck operated segments from Forst to the four municipalities of the Posnan metropolitan area. Those costs represent the highest cost category at 27.19%.

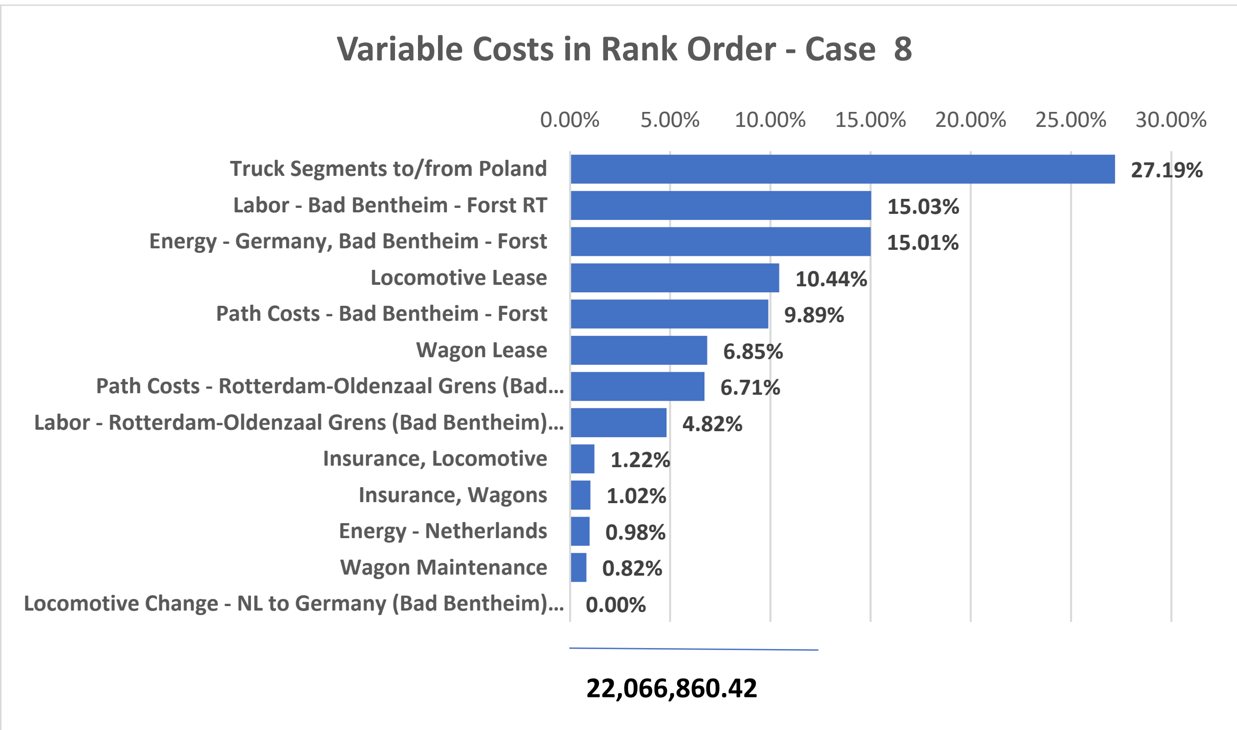


Figure 41: Variable Costs Detail, Case 8

The second largest cost category are the labor costs over the German trip segments at 15.03% and 4.82% for the labor costs incurred in the Netherlands to the Port of Rotterdam. Combined, the labor costs are 19.86% vs. the equivalent Case 3 of 23.92% with the same O/D pairs, which are very similar, the difference being that the last segment to/from Poland is handled by trucks.

The third largest cost category are the energy costs over the German trip segments (15.01%) and combined with .98% in the Netherlands, total 15.99%. This compares with 23.80% in Case 3, which is the equivalent case for this O/D pair using rail vs. rail and truck. The energy costs have some potential for reduction, depending on what locomotives are available and the paths through Germany, but in this case, diesel electric locomotives must be used, due to portions of the DB route to Forst not being electrified.

The locomotive lease is the fourth largest cost component in Case 8 at 10.44% and combined with the wagon leases at 6.85%, the combined total is 17.29%. In proportion, this is compared to Case 3 at 22.72%.

Path costs represent the fifth highest cost category at 9.89% for Germany and 6.71% for Netherlands, with a combined total of 16.60%. Compared to the equivalent Case 3, the combined total path costs are 24.47%, so, Case 8 is 16.60% and Case 3 is 24.47%. This is equally obvious, as the path segment through Poland is not being operated over rail. Another reality noted is that path costs are substantially higher in the Netherlands, compared to Belgium.

Comparing total operating costs for Case 8, €22,066,860.42 vs. Case 3, €16,798,817.98, the difference is mainly because of the trucking cost over the final trip segment to/from Forst Germany and Posnan Poland. The impact on profitability will be addressed in **Chapter 7 – Conclusions.** A summary of variable cost categories is shown in **Figure 42**, below.

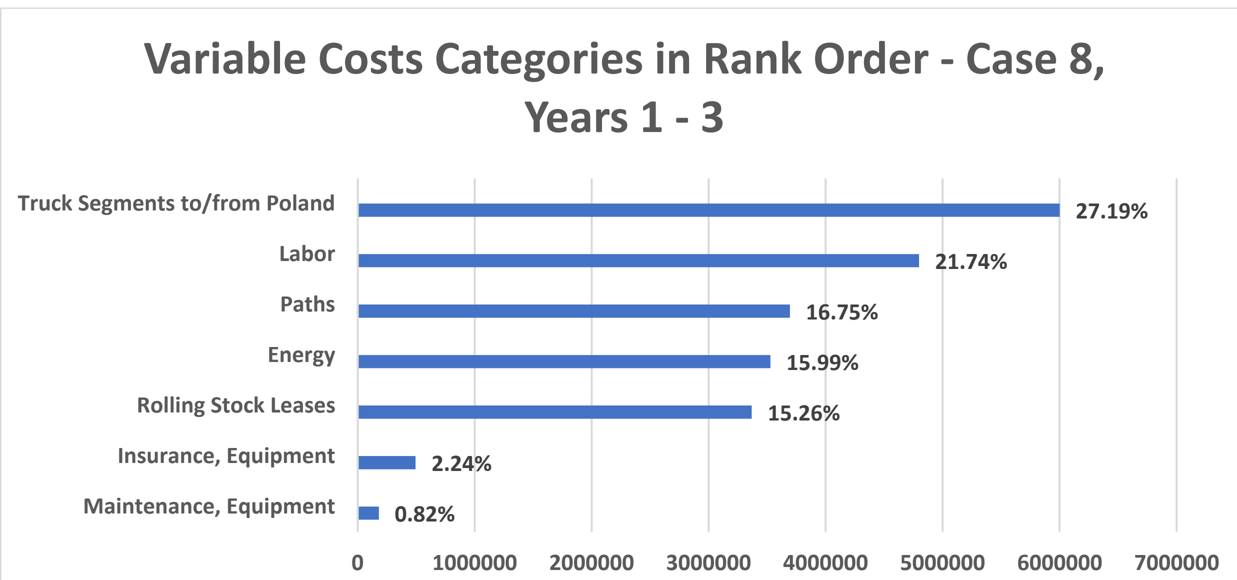


Figure 42: Variable Cost Category Summary, Case 8

6.7 Cost Analysis Simulation Tools – Step 9

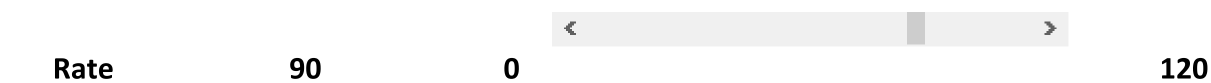
This section is a description of the cost analysis simulation spreadsheet tool developed for this dissertation to confirm or reestablish new parameters combinations for analysis. The tool will yield the optimum two metrics over a time series for the overall financial performance of each case over the entire span of three years, given the cost and revenue variables, as well as the later provision of the same metrics for each one of three years, as required. The two metrics are:

- Breakeven revenue
- Breakeven in loading units (trailers or containers)

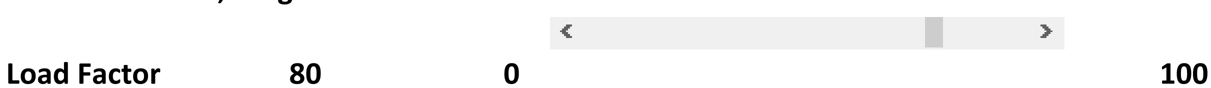
6.7.1 Cost Analysis Simulation Tools for Cases 1 - 4

Specifically for Cases 1- 4 and within each yearly scenario, using slide bars, the cost analysis spreadsheet simulation tool (costing model) makes it possible to vary the scenario along three parameters:

a. Rate (price) per trailer; range from 0 to €1,20 per kilometer



b. Load factor; range from 0 – 100%



c. Number of wagons per trainset; range from 0 to 22 wagons

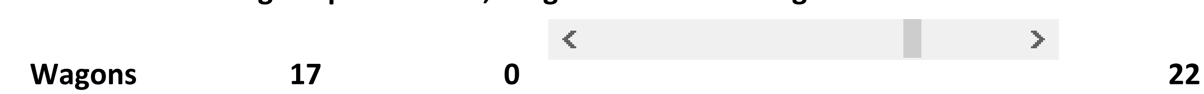


Figure 43: Slide Bar Selection Screen, Cases 1–4

The slide bars, as shown above, control each combination of variables and are dynamically linked to the data in each case, which in turn, is linked to a graph representing the breakeven points for both revenue and loading units over the three-year span of the case.

Each of the cost elements examined in the cost structure, as described within **Section 6.6** are targets for reduction, which will ultimately flow down to reflect in the breakeven analysis points, each of which contribute to a downward movement of their combined influence on the breakeven point in the graph.

This aspect of the tool is quite useful to the research seeking to examine the effect of a combination of variables changing, either individually or in combination.

With the tools in the spreadsheet, a researcher can determine:

1. Cost comparisons of different train lengths *and* loading units
2. Cost and cost changes in proportional percentage, for each operational scenario
3. Cost per line segment for each scenario
4. Any combination of the above

6.7.2 Cost Analysis Simulation Tools for Case 5 – 8

The simulation tools for Cases 5 – 8 are identical to the tools used for Cases 1 – 4, but with an added feature. Because these cases involve the cargo moving by truck over the trip segments in Poland to and from Germany, two additional slide bars have been added to specifically accommodate the possibility of additional revenue generated by handling truck trailers independently of a freight forwarder, logistics firm or trucking firm using the rail service to or from the Ports of Antwerp or Rotterdam.

There are two slide bars to simulate traffic independently in an easterly (towards Poland from Forst, Germany), or westerly, (from Poland to Forst, Germany), where the trailers hauled by independent hauliers by truck, *from any origin*, can be accommodated.

a. Rate (price) per trailer; range from 0 to €1,20 per kilometer

Rate 90 0 120

b. Load factor; range from 0 – 100%

Load Factor 100 0

c. Extra Trailers E; range from 0 to 50 trailers

Trailers 17 0 50

d. Extra Trailers W; range from 0 to 50 trailers

Trailers 17 0 50

Figure 44: Slide Bar Selection Screen, Cases 5 – 8

As with Cases 1 – 4, the slide bars, as shown above, control each combination of variables and are dynamically linked to the data in each case, which in turn, is linked to a graph representing the breakeven points for both revenue and loading units over the three-year span of the case.

Each parameter setting will ultimately flow down to reflect in the breakeven analysis points, each of which contribute to movement of the breakeven point in the graph that illustrates their combined influence. This additional feature adding independent trailer traffic will be useful to the research seeking to examine the effect of new traffic revenue, as well as a combination of variables changing, either individually or in combination.

The utility of this tool can be applied to achieve multiple objectives. Aside from the cases of evaluating independent variable combinations, this tool could also be used assess the effects of new public sector policy conditions on RUs, such as increased (or decreased) costs through taxation, energy and path costs.

As mentioned above, non-governmental labor and local costs, such as switching different locomotives to the train at border crossings are also considered.

In the case of determining market sensitivity, diminished revenue conditions, due to competitive conditions are easily varied to assess that effect on RU. Similarly, if market conditions allow for increased rates per kilometer, the slide bars can be adjusted for the new rates.

In conclusion, this tool can serve to be useful to assess:

- The effects of various independent cost variables on profitability
- The effects of governmental policies, manifesting in public charges and effects on profitability
- A sensitivity analysis of updated cost variables values on profitability

# Trainsets Leased	2	2	2	2	2	2	2	2	2	2	2	2	
# Train segments per week	4	4	4	4	4	4	4	4	4	4	4	4	48
Total Trainset segments/Mo	8	8	8	8	8	8	8	8	8	8	8	8	96
Wagons per Trainset	17	17	17	17	17	17	17	17	17	17	17	17	204
Trailers per Trainset	34	34	34	34	34	34	34	34	34	34	34	34	
Trailers per Month	544	544	544	544	544	544	544	544	544	544	544	544	6528
Revenue	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Total 2020

Figure 45: Header Variable Selection from Simulation Spreadsheet

By entering values into the first two rows of the header, the researcher can select the **trainsets required** and **trainsets per week** (each segment in each direction * the trainsets = trainsets), which then become the basis upon which revenue is calculated.

Case 1 - Year 1 **Revenue**

Origin	Destination	Kilometers	Rate/Km	Wagons	Trailers/ Wagon	Total Trailers	Load Factor	Total Revenue	Rev/Unit
Rotterdam	Wroclaw	966	€ 0,90	17	2	34	80%	€ 23.647,68	€ 695,52
Wroclaw	Rotterdam	966	€ 0,90	17	2	34	80%	€ 23.647,68	€ 695,52

Notes: Pocket wagons with 2 trailers each

Figure 46: Revenue Calculated from Variable Selection from Slide Bar

Movement of any of the corresponding horizontal slide bars shown in **Section 6.7.1, Figure 43** will result in a change of the **rate per kilometer**, **number of wagons** in the train and the **load factor**, respectively, in the basis on which those values are calculated.

Fixed Cost		€ 486,550.00				
Variable Cost per Trailer		€ 580.98				
Price per Trailer		€ 695.52				
Increments		400				
Breakeven Number of Trailers		4248				
Breakeven Revenue		€ 2,954,386.41				
Time	**Trailer Start #**	**Trailer Increm.**	**Trailer Price**	**Trailer Var Cost**	**Fixed Costs**	
Year	0	400	€ 695.52	€ 580.98	€ 486,550.00	
Trailers	**Revenue**	**Variable Cost**	**Contrib. Margin**	**Fixed Cost**	**Total Cost**	**Net Revenue**
0	€ -	€ 0.00	€ -	€ 486,550.00	€ 486,550.00	€ (486,550.00)
400	€ 278,208.00	€ 232,390.67	€ 45,817.33	€ 486,550.00	€ 718,940.67	€ (440,732.67)
800	€ 556,416.00	€ 464,781.34	€ 91,634.66	€ 486,550.00	€ 951,331.34	€ (394,915.34)
1200	€ 834,624.00	€ 697,172.00	€ 137,452.00	€ 486,550.00	€ 1,183,722.00	€ (349,098.00)
1600	€ 1,112,832.00	€ 929,562.67	€ 183,269.33	€ 486,550.00	€ 1,416,112.67	€ (303,280.67)
2000	€ 1,391,040.00	€ 1,161,953.34	€ 229,086.66	€ 486,550.00	€ 1,648,503.34	€ (257,463.34)
2400	€ 1,669,248.00	€ 1,394,344.01	€ 274,903.99	€ 486,550.00	€ 1,880,894.01	€ (211,646.01)
2800	€ 1,947,456.00	€ 1,626,734.68	€ 320,721.32	€ 486,550.00	€ 2,113,284.68	€ (165,828.68)
3200	€ 2,225,664.00	€ 1,859,125.35	€ 366,538.65	€ 486,550.00	€ 2,345,675.35	€ (120,011.35)
3600	€ 2,503,872.00	€ 2,091,516.01	€ 412,355.99	€ 486,550.00	€ 2,578,066.01	€ (74,194.01)
4000	€ 2,782,080.00	€ 2,323,906.68	€ 458,173.32	€ 486,550.00	€ 2,810,456.68	€ (28,376.68)
4400	€ 3,060,288.00	€ 2,556,297.35	€ 503,990.65	€ 486,550.00	€ 3,042,847.35	€ 17,440.65
4800	€ 3,338,496.00	€ 2,788,688.02	€ 549,807.98	€ 486,550.00	€ 3,275,238.02	€ 63,257.98
5200	€ 3,616,704.00	€ 3,021,078.69	€ 595,625.31	€ 486,550.00	€ 3,507,628.69	€ 109,075.31
5600	€ 3,894,912.00	€ 3,253,469.35	€ 641,442.65	€ 486,550.00	€ 3,740,019.35	€ 154,892.65
	Breakeven X	**Breakeven Y**	**Label**			
	4248	€ 2,954,568.96	Breakeven About 4248 Trailers and Revenue €2954568.96			

Figure 47: Calculations as Basis Breakeven Analysis - Case 1, Year 1

Any changes in the values selected in the tools shown in **Sections 6.6.1** and **6.6.2** will reflect in the matrix of revenues, costs and metrics shown above in **Figure 47**, above. This resulting table then becomes the underlying basis for the breakeven chart.

It is also here at the bottom row of this table that calculations identifying breakeven points for **trailer volume** and **revenue** are shown, along with a label to insert into the chart, dynamically linked to the underlying numbers, so that the **label values** change with different inputs.

Figures 48 to 51 show the breakeven points for each of the three years in **Scenario Case 1** and breakeven points over the entire three-year period examined in **Figure 51**. The breakeven analysis graphs of the each of the three years for Case 1 was to show the capability of the cost simulation model to breakdown each of the three years, although for this dissertation, the objective is to assess each case scenario's overall financial performance over the entire three-year timeline.

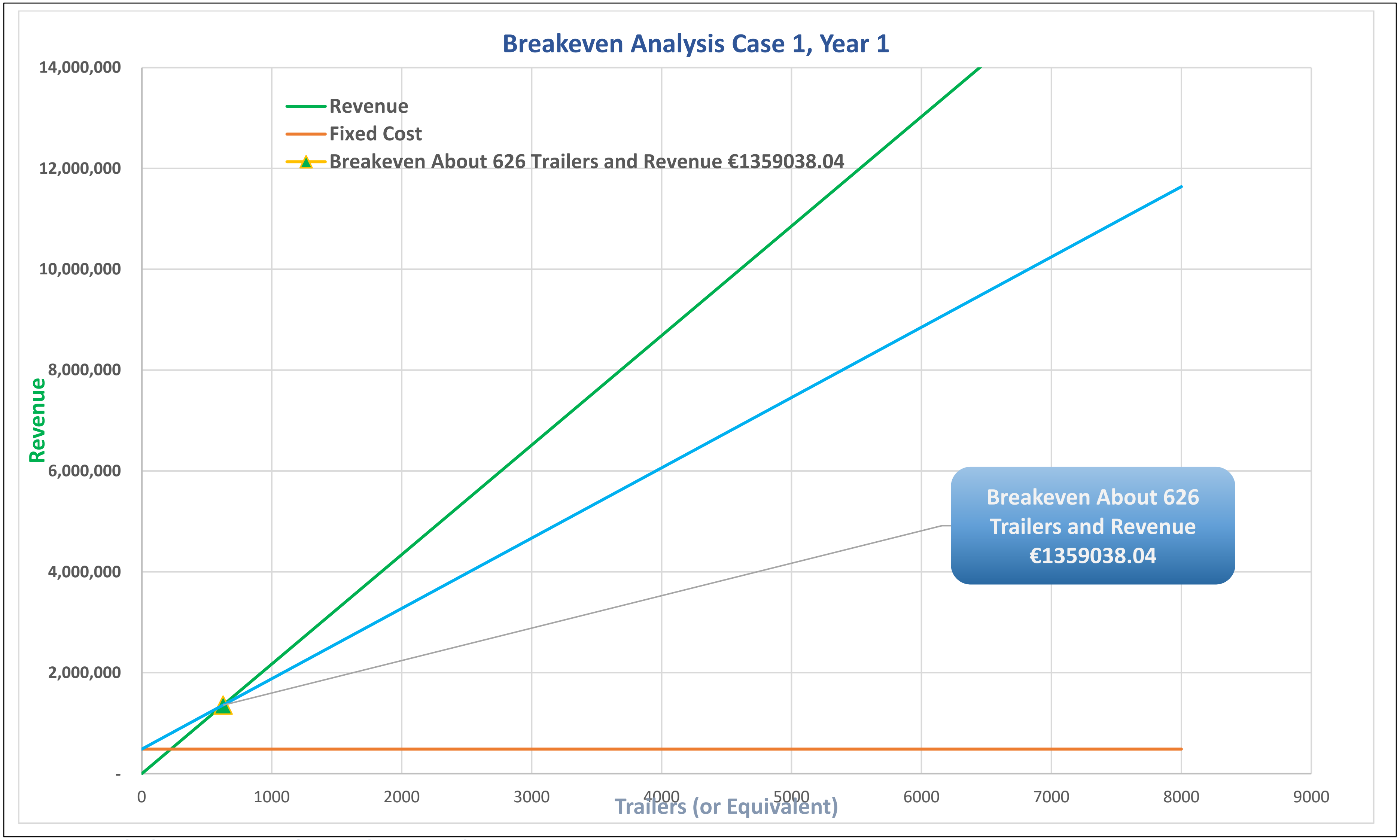


Figure 48: Calculations as Basis for Breakeven Analysis - Case 1, Year 1

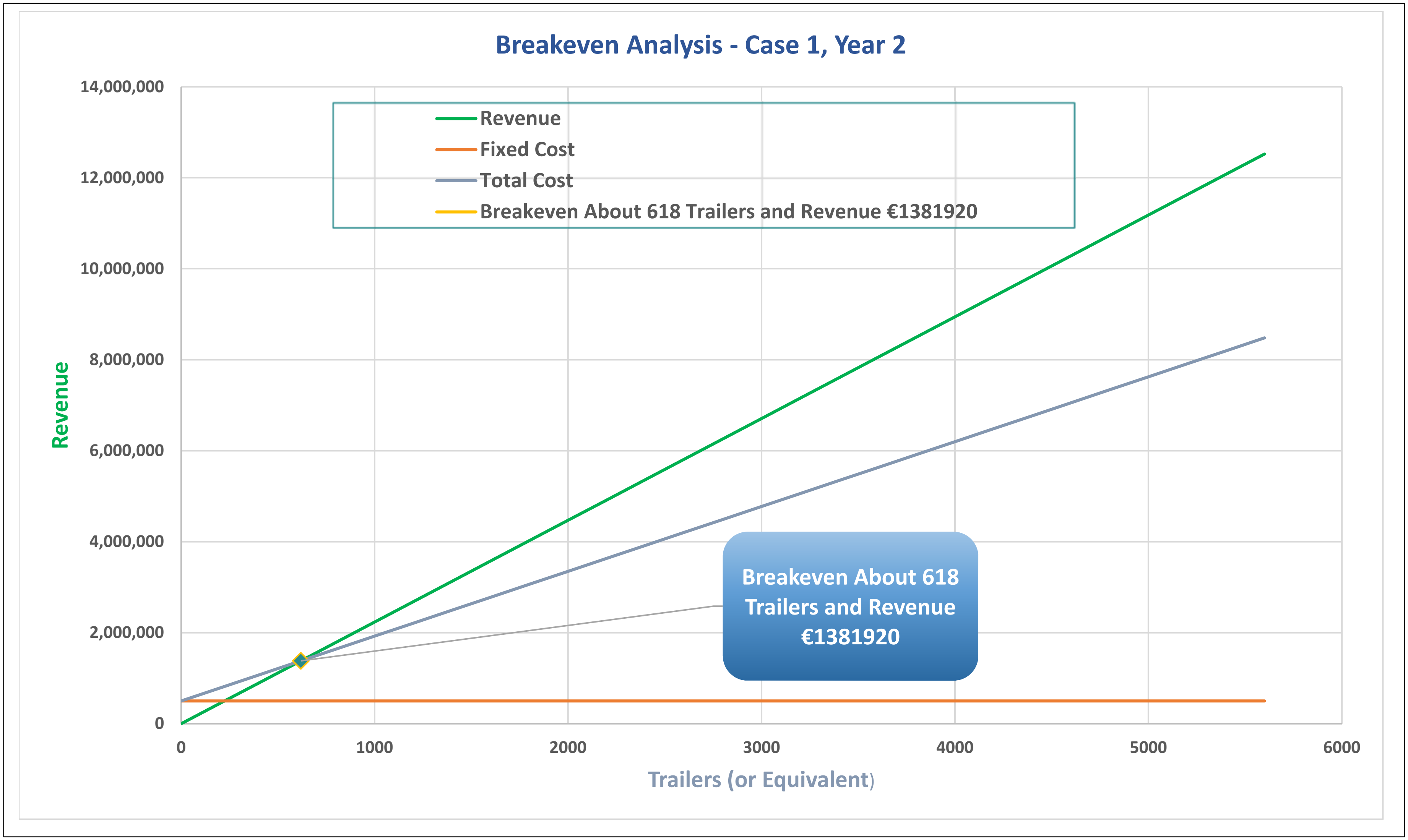


Figure 49: Calculations as Basis for Breakeven Analysis - Case 1, Year 2

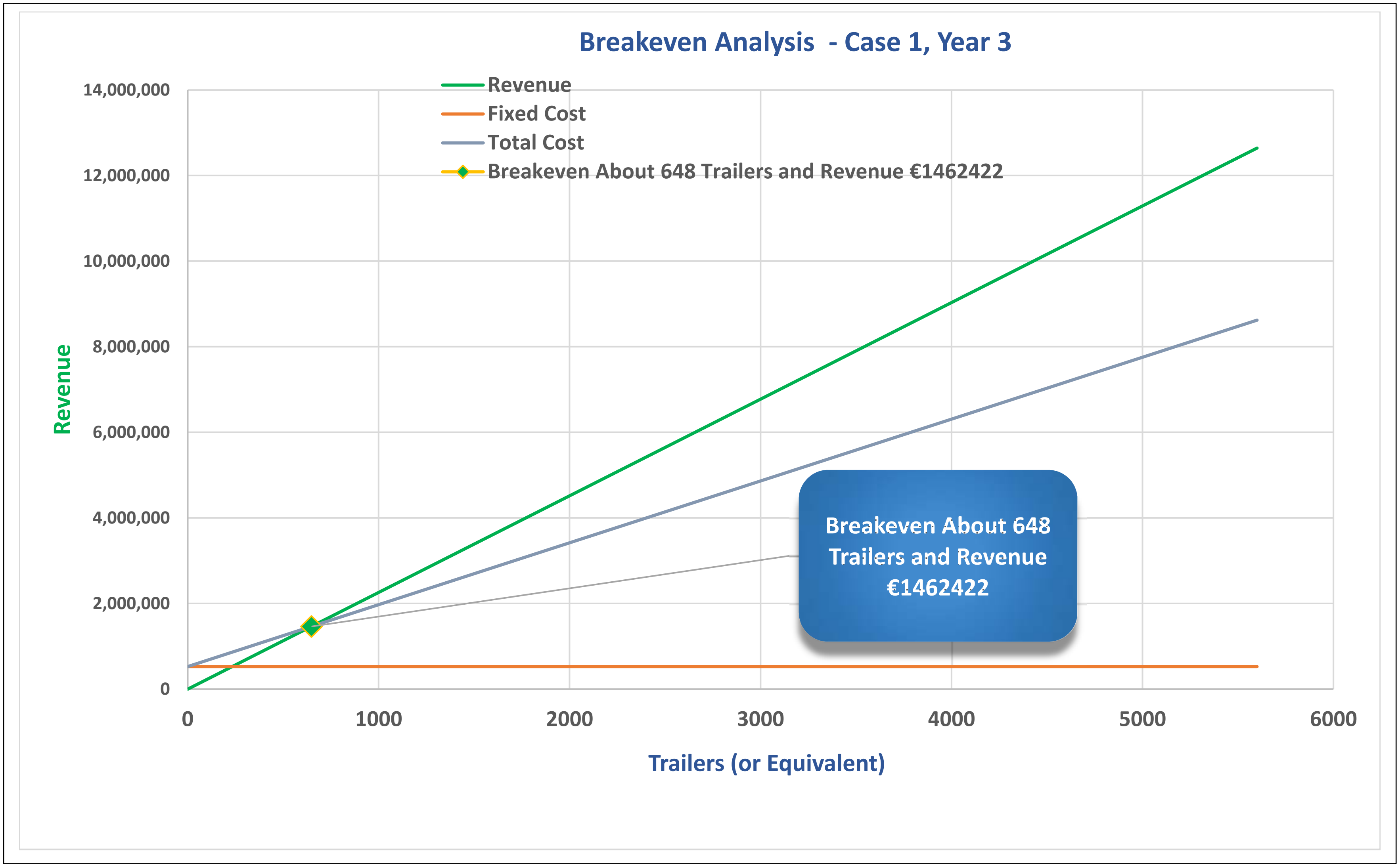


Figure 50: Calculations as Basis for Breakeven Analysis - Case 1, Year 3

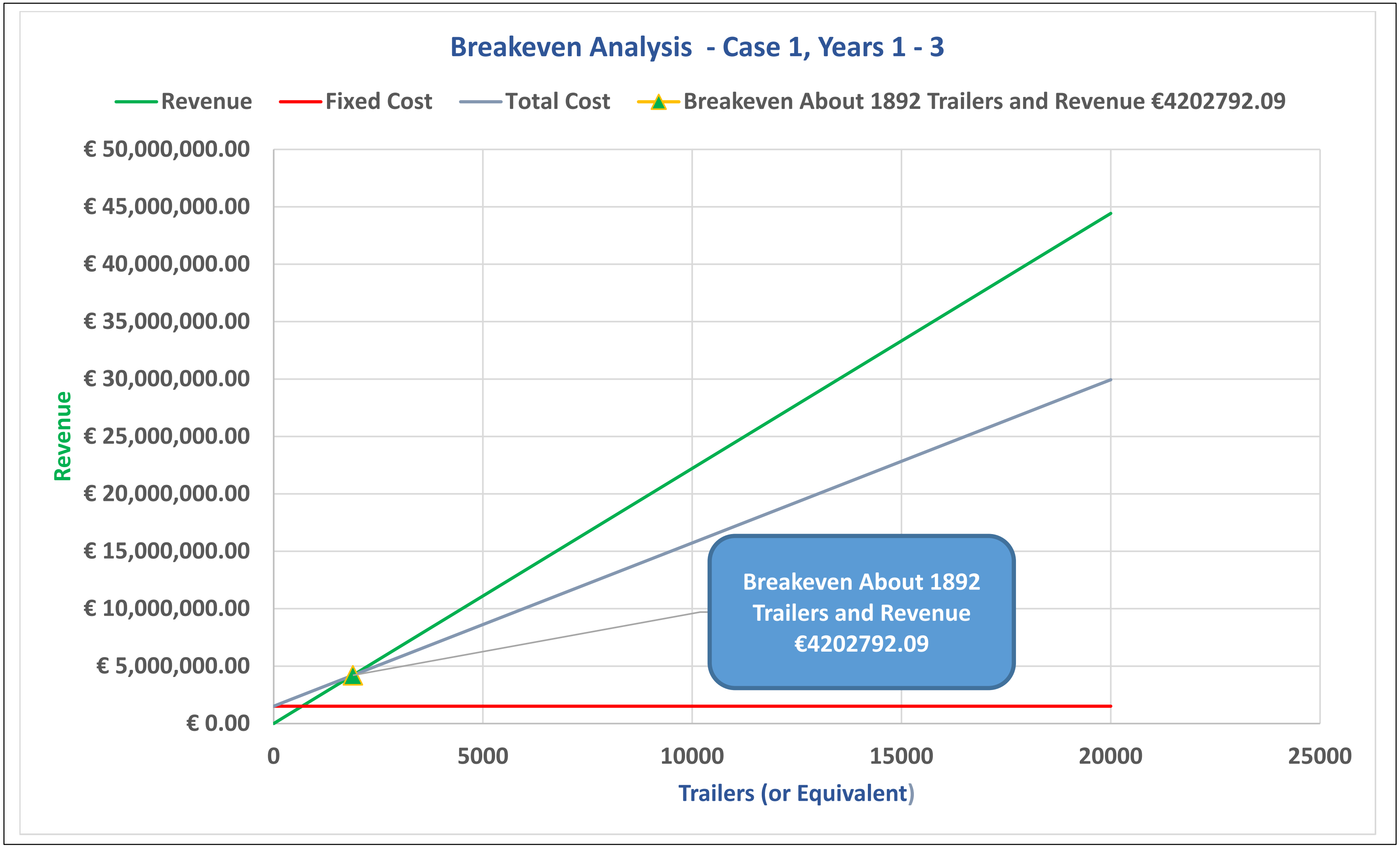


Figure 51: Calculations as Basis for Breakeven Analysis - Case 1, Years 1 - 3

6.7.3 Relationship of Profit to Cost Categories

The approximate and relative relationship of Profit (Loss) to costs is illustrated in the graph below that shows the overall proportion of Profit (Loss) to the highest categories of costs. Note the distance between the Profit (Loss) line to the lines of costs clusters in the cases, for a perspective on financial performance.

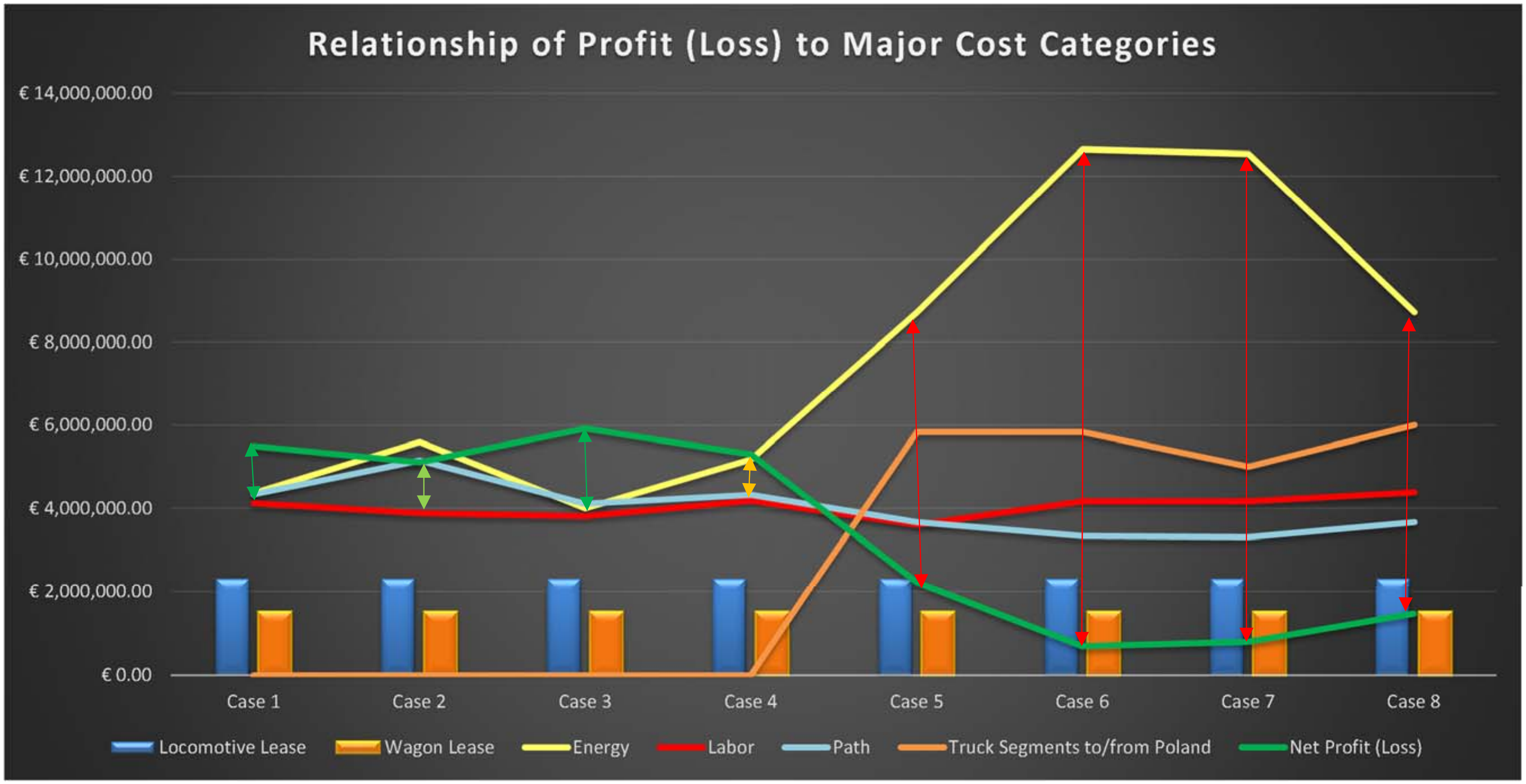


Figure 52: Relationship of **Profit** (**Loss**) to Major Cost Categories

6.7.4 Relationships of NPV and IRR to Case Scenarios

The comparison between the NPV and IRR relative to the case scenarios is illustrated below in Figure 53.

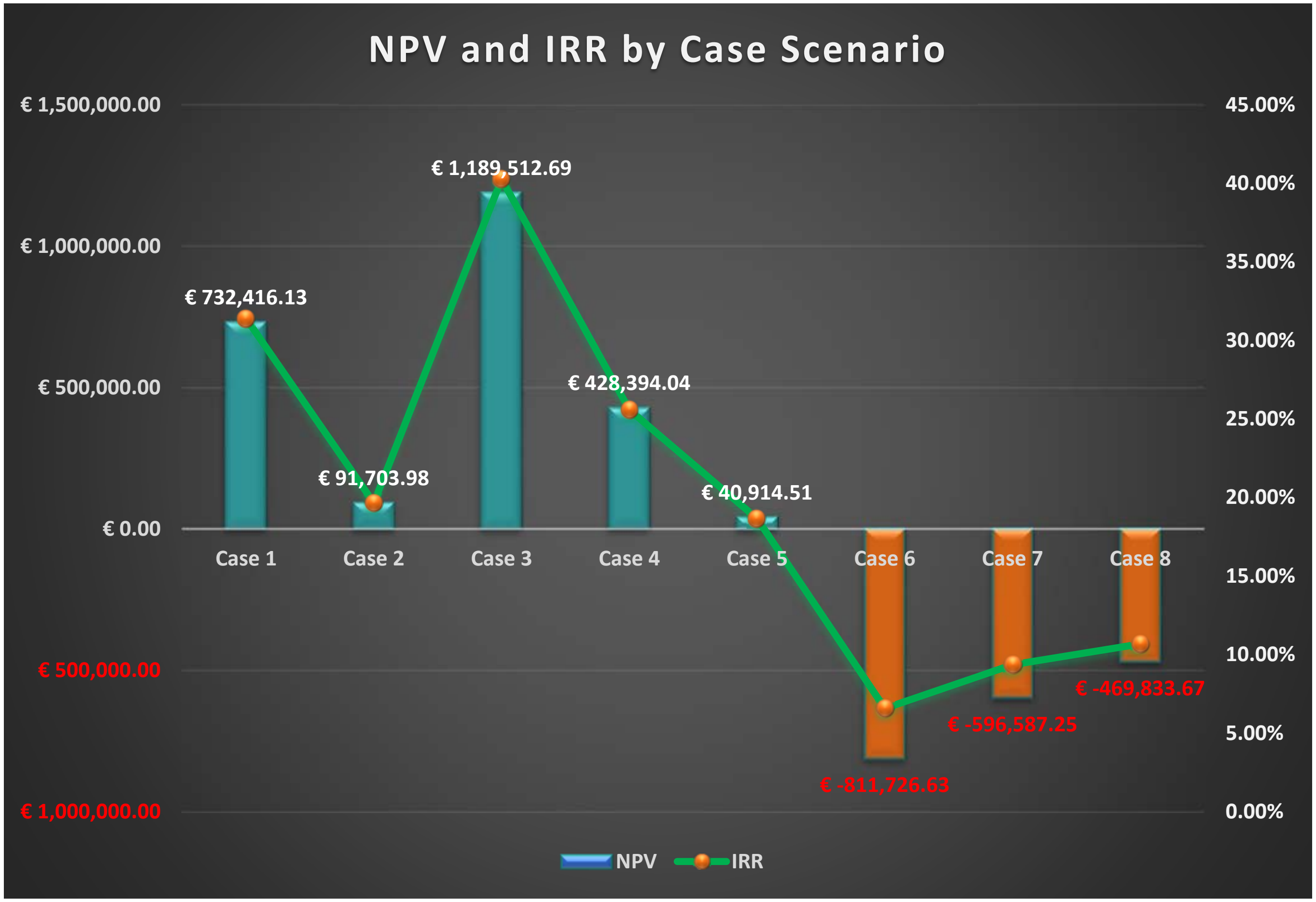


Figure 53: NPV and IRR by Case Scenario

6.7.5 Elasticity

Looking at the competitiveness of the rail mode, we must determine elasticities, comparing rail to truck modes, which fall into the cross-elasticity category and the ranges. For elasticities, overall, these factors are relevant:

1. Long term: elasticities are larger over the long term, for which much rail freight transport is based. [69]

2. GDP: the relationship between two discrete variables, GDP and industrial production is well established. The general elasticity of transport demand in relationship to GDP is 1.27 and specifically for rail freight and related more to industrial production is between .6 and 1.[70]

3. Long distance road transport, related to distance bands most applicable to rail transport and similar competitive scenarios. For distances greater than 300 km, multimodality should be the focus. In 2005, a road tax ranging from 9 – 14 Eurocents was established in Germany for GVW trucks greater than 12 tons. Quoting: "*The ZEW study, based on an econometric analysis of an empirical survey among 500 German forwarders encompassing a long range of attributes shows that the charge led to a 7% increase in road transport costs and a 0.8% increase in the costs of combined transport*. *The study shows an increase of the share of combined transport in the sample by 1-2 percentage points."*[71]

4. The types of goods transported can affect elasticities. Over longer distances and higher value goods, one might expect higher elasticity, since the objective of minimizing costs for higher value goods, with respect to value of time (VOT), would be to minimize storage costs, not transport costs, relative to the value of the goods transported. However, there are changes in the supply chain that make the higher value goods sensitivity to transport price even more meaningful. If, for example, a supplier/shipper decides that the high value goods should be moved closer to the market and/or to DCs closer to the marketplace, then transport to the DCs from point of entry (a port) and/or value-added content (packaging, bundling, consolidating, final assembly), will be more

[69] ***"A survey of recent estimates of price elasticities of demand for transport"***, Oum et al., World Bank (1990), p. 11 – 13.
[70] Work package 5: ***Regulation Deliverable 5.4 - Scenario "Medium Case",*** TPR - UA (2018), Page 3, paragraph 2.
[71] den Boer, Felco et al*.,* ***"Potential of Modal Shift to Rail Transport"***, Delft (2011), Page 31, paragraph 5.

sensitive to costs, making elasticities yet higher for high value goods, for production continuity reasons, as well.

5. Traffic composition trends that have developed also influence elasticities. With sharply increased transport rates, shippers have sought to compensate by increasing the density of shipment composition within the loading units, which, in turn, increases the value of the shipment. The increase in shipment value per loading unit means higher elasticity, because VOT is higher.

6. For this analysis, we must select which elasticities to examine, related to the types of traffic we are targeting. We could look at the segments of commodity, distance bands, geographies, which all might have different substitution choices. In this case, cross elasticities are the appropriate measure, as own price is not relevant, since most logistics choices are outsourced by shippers, anyway.

7. In general, consider how much the cost element being evaluated is represented in the entire cost structure of a transport mode. The cost element with the largest proportion of overall costs will affect elasticity the most and one of the factors to examine is in modal choice, especially as regards terminal costs. If a shipment is multimodal, there will be PPH costs and to the degree they can be minimized, that will affect the competitiveness of the mode, especially if the objective is to draw growth from truck container traffic. In the case scenarios depicted, the terminal cost will not be a factor, since in **Cases 5 – 8**, the shipper/customer/logistics company will have that cost embedded in that cost for their truck transport segments. (See #8, the next point). [72]

8. Considering the above, one would have to analyze the sensitivity of the main mode vs. the individual elements of each trip mode (segments). What is the total cost of the trip and main modes, which include PPH and terminal costs? (See **Section 4.1.8 Pre and Post Handling** for clarification on this point).

9. One must consider an entire region of a country, in the case of comparisons in the US and international (within the EU), for European traffic, as in EU-wide. A focus inward in some transport markets in CEE countries on complementary industries within those respective countries (or regions), keeps many transport O/D pairs short, which are

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[72] ***"On the generalized cost – demand elasticity of container transport"*** Jourquin, Tavasszy and Duan (2014) P.11-12 (372-373)

conditions that favor trucks, rather than rail. (This is a market opportunity that rail, whether in the EU, the US or any country or region with density, can compete with trucks with fast, light and frequent rail service).

Though there is a plethora of elasticity data for road freight, there is relatively little for rail. In addition, market conditions are very dynamic and therefore difficult to apply a "catch-all" elasticity value on a broad basis. From reviews of the literature, the appropriate category of elasticities to apply is the transport cost elasticity of rail ton-km and the range is elastic at values of **1.7 – 2.4** de Jong (2010).[73]

When generalized costs for road reduce by 5%, own elasticity of road transport is estimated at -.51 and for cross-elasticity for rail-road (CT), cross-elasticity is estimated at .61.[74]

In summary, price elasticity of road vs. rail freight transport is affected most by these factors:[75]

- ***Differences in independent variables***
- ***Difference in response mechanisms***
- ***Differences between countries e.g., what substitution options exist, such as rail, IWW or SSS***
- ***Differences in commodities***
- ***Differences in distance bands***

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[73] ***"Price Sensitivity of European Road Freight Transport-Towards a Better Understanding of Existing Results"***, de Jong **(2010)** Page 26

[74] ***"On the generalized cost – demand elasticity of container transport"*** Jourquin, Tavasszy and Duan (2014) P.6 (367)

[75] **Source:** Self with Notes from **"*Modal Shift Target for Freight Transport Above 300 km – an Assessment*"** Discussion Paper – 17th ACEA SAG Meeting – **7 September 2011**

6.7.6 Cost Analysis Conclusions

The general conclusions are illustrated in the two separate graphs to compare O/D pairs served by rail only, Cases 1 – 4 and O/D pairs served by both rail and in Poland, by a short remaining distance from Germany by truck for Cases 5 - 8. From the graphs, it will not be difficult to compare which cases have the highest costs in each major category group.

In ***Figure 54 – Major Cost Category Comparison - Cases 1 – 4,*** it is easy to see why **Case 3** is the most profitable of the group, because it has lower labor, path and energy costs. The lower labor costs come from faster transit times, lower path costs are because of a less circuitous route via Bad Bentheim, the border between Netherlands and Germany and the lower energy costs are due to the use of electric locomotives, over more direct paths, combined with a slightly shorter distance from the German border to Posnan.

Cases 3 and 4 also have equipment lease costs that are proportionately lower, relative to the comparative percentage of costs over the highest cost categories. According to the data, the equipment lease costs have a strong effect over the entire spectrum of cost categories.

Case 2 has the highest energy and path costs, relative to the other cases. The labor and equipment lease costs are on par with other cases 1, 3 and 4. While it ranks fourth of all cases, it nevertheless has a positive NPV and IRR.

Case 1's equipment lease costs are relatively higher than Cases 3 and 4, but energy costs are the second lowest of this group of four and the path costs are either nearly on-par with Case 4 and are lower than Case 2, resulting in the second highest NPV and IRR.

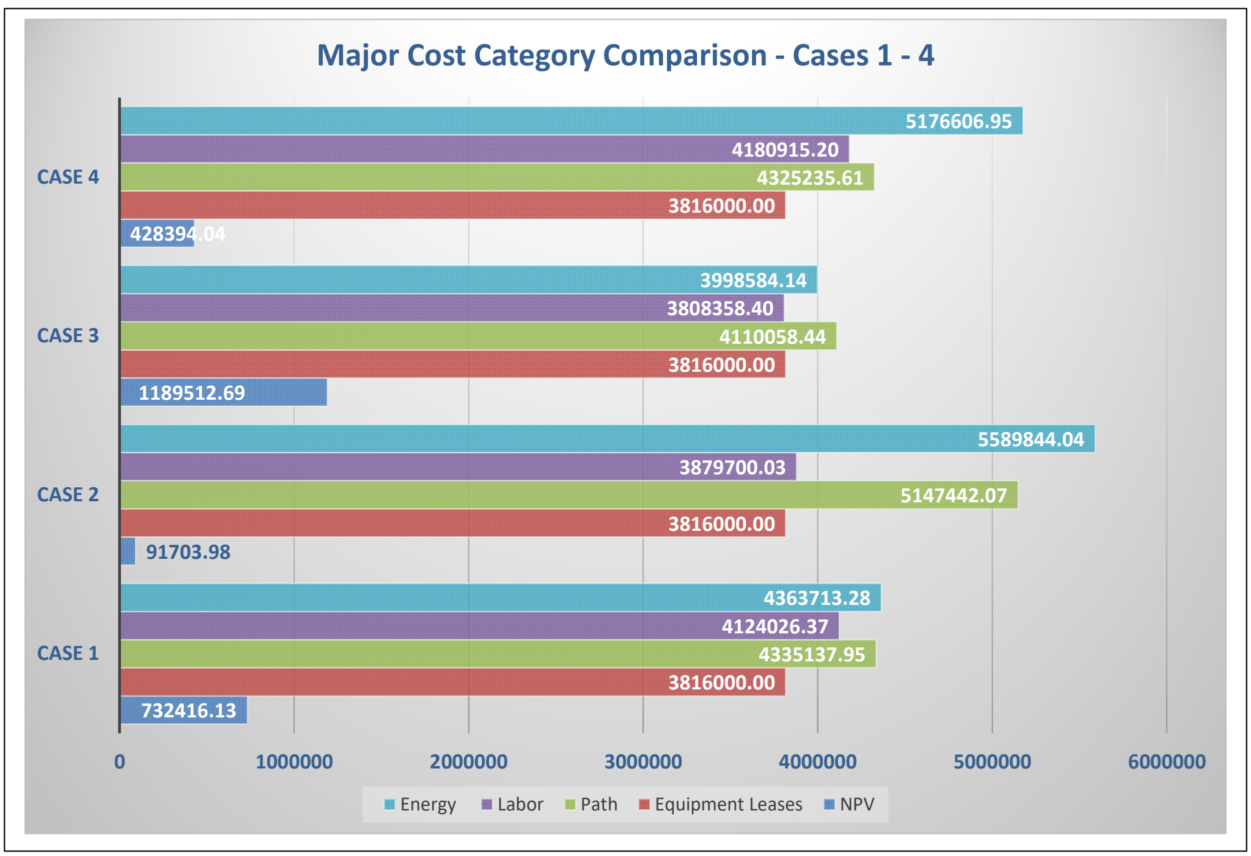


Figure 54: Major Cost Category Comparison - Cases 1 - 4

Similarly, as illustrated in ***Figure 55 – Major Cost Category Comparison - Cases 5 – 8,*** Case 5 emerges as a profitable case, principally due to lower energy and labor costs. Cases 6, 7 and 8 are not profitable, due to high energy costs and trucking to/from the Polish O/D pair. Cases 5 – 8 have lower overall path costs, due to the shorter distance from Forst Germany to Posnan or Wroclaw, but not low enough to offset the additional trucking costs.

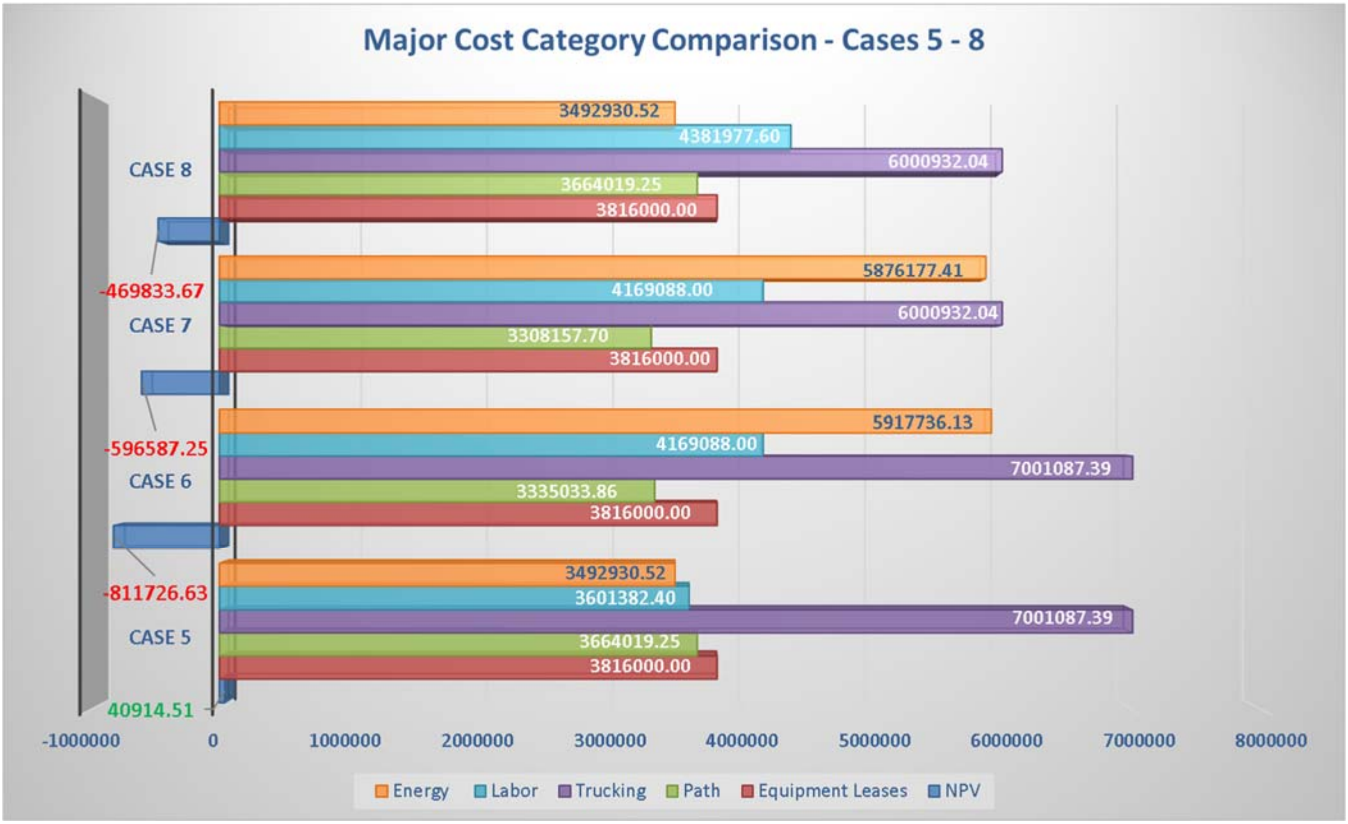
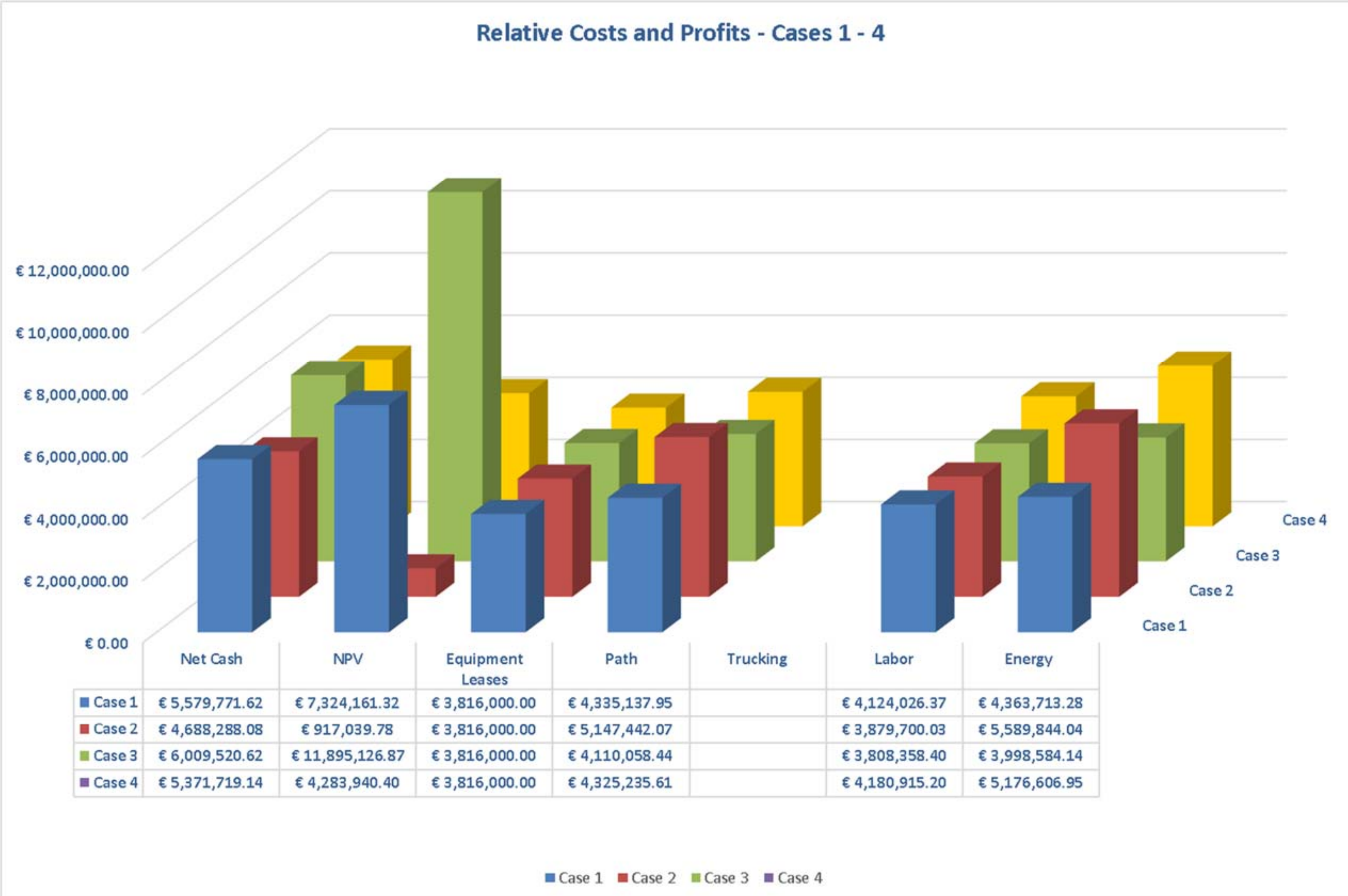


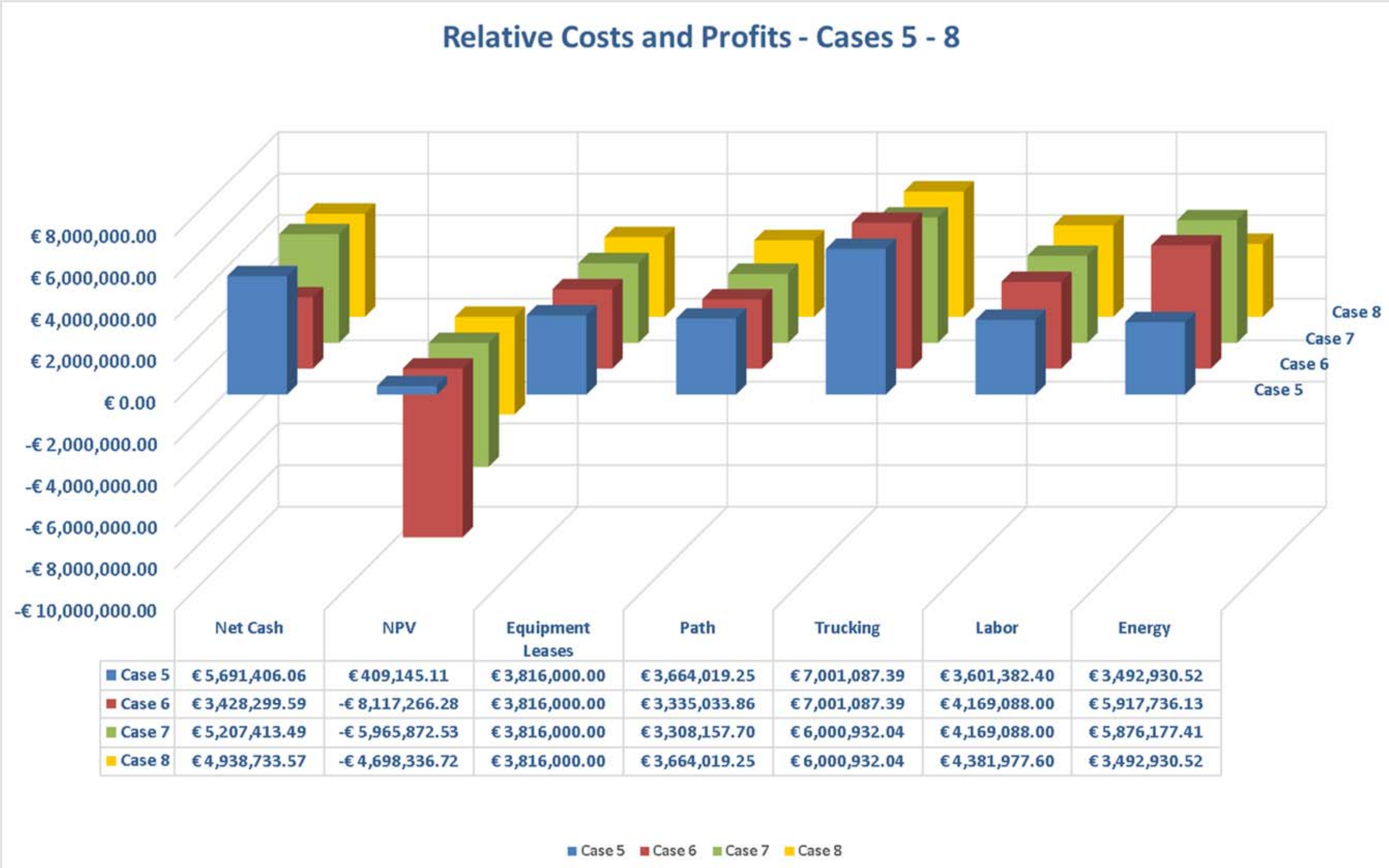
Figure 55: Major Cost Category Comparison - Cases 5 - 8

The graphs on the following two pages, ***Figure 56 - Relative Costs and Profits - Cases 1 – 4*** and ***Figure 57– Relative Costs and Profits - Cases 5 – 8,*** illustrate the relative relationships between the major cost categories of each case category. A note on two data categories, net cash and NPV. The net cash figure is the aggregate amount of cash generated during the three-year period analyzed, but does not necessarily reflect the overall profitability of the cases. To properly assess profitability, one would need to consider the NPV and IRR values. The NPV figure would indicate whether the initial capital invested would be recovered (for which the NPV value must be at or above zero), and the IRR would measure the overall return on the capital itself, both metrics given the discount rate. Another note is that the actual NPV value calculated by the cost simulation model has been *multiplied by a factor of 10 for illustrative purposes* to make the graphs more meaningful and offer contrasting perspectives. Cases 6 – 8 have negative NPV values, indicating that the initial invested capital has *not* been completely recovered.



	Net Cash	NPV	Equipment Leases	Path	Trucking	Labor	Energy
Case 1	€ 5,579,771.62	€ 7,324,161.32	€ 3,816,000.00	€ 4,335,137.95		€ 4,124,026.37	€ 4,363,713.28
Case 2	€ 4,688,288.08	€ 917,039.78	€ 3,816,000.00	€ 5,147,442.07		€ 3,879,700.03	€ 5,589,844.04
Case 3	€ 6,009,520.62	€ 11,895,126.87	€ 3,816,000.00	€ 4,110,058.44		€ 3,808,358.40	€ 3,998,584.14
Case 4	€ 5,371,719.14	€ 4,283,940.40	€ 3,816,000.00	€ 4,325,235.61		€ 4,180,915.20	€ 5,176,606.95

Figure 56: Relative Costs and Profits - Cases 1 - 4



	Net Cash	NPV	Equipment Leases	Path	Trucking	Labor	Energy
Case 5	€ 5,691,406.06	€ 409,145.11	€ 3,816,000.00	€ 3,664,019.25	€ 7,001,087.39	€ 3,601,382.40	€ 3,492,930.52
Case 6	€ 3,428,299.59	-€ 8,117,266.28	€ 3,816,000.00	€ 3,335,033.86	€ 7,001,087.39	€ 4,169,088.00	€ 5,917,736.13
Case 7	€ 5,207,413.49	-€ 5,965,872.53	€ 3,816,000.00	€ 3,308,157.70	€ 6,000,932.04	€ 4,169,088.00	€ 5,876,177.41
Case 8	€ 4,938,733.57	-€ 4,698,336.72	€ 3,816,000.00	€ 3,664,019.25	€ 6,000,932.04	€ 4,381,977.60	€ 3,492,930.52

Figure 57: Relative Costs and Profits - Cases 5 - 8

6.8 Sensitivity Analysis of Cost Variables – Step 10

Referring to Section 6.6.2 – General Variable Costs in Rank Order, a determination had to be made on which cost variables to analyze. The four most prominent were:

a. Equipment leases
b. Paths
c. Labor
d. Energy

Equipment leases were not likely to be reduced, due to the nature of these transactions, in which an RU would have the choice of either a short-term lease to avoid committing to a fixed cost for customers that may or may not materialize and/or continue the relationship, if already started. Short term leases are generally costlier than a long-term lease commitment. A long-term lease would be fixed in price, anyway, so there would unlikely be latitude for reducing cost.

Labor costs rarely diminish and realistically, if an RU were to attempt to reduce the rate of pay for operating crews, there would be union, political and productivity implications that would be difficult to manage. In many cases, crews are increasingly supplied by enterprises who specialize in supplying drivers and other operating crews on contract and therefore, the costs would not be flexible.

Path cost reductions do have some possibility, as evidenced by DB Netz recently reducing network access charges by 98% to RUs due to the recent pandemic. The network authorities understand the many difficulties encountered by not only the pandemic, but also the many obstacles that RUs encounter with market conditions, increased energy costs and regulatory burdens. Network authorities have temporarily reduced access charges, but these conditions should be considered temporary. However, the current reduced access charges give a good point to start with at 2% of the previously imposed access charges and applying increments of 2%, 50%, 100% and 150% of the previous access charge, with 100% being the index rate, that is, 100% of the previously imposed rate. For this sensitivity analysis, these multiples are applied to the index rate.

The other cost variable that RUs may have some control over is energy. Energy costs can be impacted by the types of locomotives used by the RU and there may also be some relief offered by network authorities to RUs, as a matter of facilitating migration of road to rail initiatives and general climate change policies. Though there is no specific evidence of that happening, there already has been a precedent set by diminished network access charges for the non-energy charges. The network authorities often bundle energy costs into the access charge, which can be extracted by observing the estimated kW energy consumption calculated on the DB Netz Trassenfinder.de website for the routes. Knowing the kW rate and consumption is helpful to calculate the impact on energy costs to RUs and make a case for demonstrating the positive or negative impact on the profitability of an RU. At first sight, the sensitivity analysis will be applied to over a range spanning from 75% to 250% in 25% increments.

However, under more recent consideration is a specific proposal for the German government, through DB Netz, to reduce or eliminate the 19% VAT tax levy on energy. Taxation of energy on a mode of transport that is already favored as a policy goal, as imposing tax is incongruous to the objective. Moreover, electrical energy for rail is burdened with triple tax in the form of:

1. German VAT of 19%
2. The provisions of the Renewable Energy Sources Act
3. Emissions trading

The Renewable Energy Sources Act provisions tax electrically powered rail traction, but neither road nor maritime shipping is affected and this competitively disadvantages rail by raising the cost floor.

Emissions trading has its origins from 2013, in which power generating stations have had to pay for CO2 allowances, the largest consumer of which are electric traction rail transport. 90% of rail transport in Germany is moved by electric traction, so the rail sector is profoundly affected by this. While items 2 and 3 are broad policy level decisions, the abatement of 19% VAT is not and, as policy, should be waived, also consistent with the low or zero taxation rates on energy of neighboring EU countries.

To include this possibility in expanding the sensitivity analysis would add one more reduction to the kW factor from the 75% level decremented by eliminating the 19% VAT, as applied to the 75% level. Therefore, (1 - .19) = .81 * .75 = .6075 as the new reduced level of kW costs. Consideration had been given to reducing the path charges, but since DB Netz has already reduced path charges by 98%, it makes sense to apply the reduction to energy costs. [76]

The sensitivity analysis will be applied to the base case of 17 wagons, €.90 rate per km and with the train operating with a load factor of 80%. A matrix of values organized by two parameters will be set up, as follows:

kW Factor	Path Factor	NPV	IRR
60.75%	2%		
60.75%	50%		
60.75%	100%		
60.75%	150%		

[76] "Total exemption of rail freight from electricity tax and from the taxation of diesel fuel used for traction can remove the high multiple burdens imposed on rail freight operators and boost their competitive position". Federal Ministry of Transport and Digital Infrastructure, ***"Rail Freight Master Plan"***, P.33-34, (2007)

75%	2%		
75%	50%		
75%	100%		
75%	150%		
100%	2%		
100%	50%		
100%	100%		
100%	150%		
125%	2%		
125%	50%		
125%	100%		
125%	150%		
150%	2%		
150%	50%		
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175%	2%		
175%	50%		
175%	100%		
175%	150%		
200%	2%		
200%	50%		
200%	100%		
200%	150%		
225%	2%		
225%	50%		
225%	100%		
225%	150%		
250%	2%		
250%	50%		
250%	100%		
250%	150%		

Figure 58: Matrix of values by two cost variables

Each of the eight case scenarios will be analyzed, as to what combinations of energy and path decreases or increases from the base rate result in profitability. The metrics of NPV and IRR will be applied to determine overall profitability of each case of the three-year span examined.

6.8.1 Case 1 – Energy and Path Costs Sensitivity Analysis

Case 1 showed some resiliency observed above the base index (100% Kw factor and 100% path factor), diminishing at the 225% rate for kW and 2% for path factor, as illustrated in Table 94.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 2,733,894.68**	**73.45%**
60.75%	50%	**€ 2,107,003.19**	**59.16%**
60.75%	100%	**€ 1,453,991.21**	**45.44%**
60.75%	150%	€ 800,979.24	32.68%
75%	2%	**€ 2,471,921.57**	**67.33%**
75%	50%	**€ 1,845,030.07**	**53.52%**
75%	100%	**€ 1,192,018.09**	**40.22%**
75%	150%	€ 539,006.12	27.79%
100%	2%	**€ 2,012,319.60**	**57.10%**
100%	50%	**€ 1,385,428.11**	**44.06%**
100%	100%	€ 732,416.13	31.39%
100%	150%	€ 79,404.16	19.44%
125%	2%	**€ 1,552,717.64**	**47.45%**
125%	50%	€ 925,826.15	35.06%
125%	100%	€ 272,814.17	22.92%
125%	150%	-€ 380,197.81	11.36%
150%	2%	**€ 1,093,115.68**	**38.29%**
150%	50%	€ 466,224.18	26.45%
150%	100%	-€ 186,787.79	14.73%
150%	150%	-€ 839,799.77	3.46%
175%	2%	€ 633,513.72	29.54%
175%	50%	€ 6,622.22	18.15%
175%	100%	-€ 646,389.75	6.77%
175%	150%	-€ 1,299,401.73	-4.32%
200%	2%	€ 173,911.76	21.14%
200%	50%	-€ 452,979.74	10.10%
200%	100%	-€ 1,105,991.72	-1.05%
200%	150%	-€ 1,759,003.69	-12.07%
225%	2%	-€ 285,690.21	13.00%
225%	50%	-€ 912,581.70	2.23%
225%	100%	-€ 1,565,593.68	-8.80%
225%	150%	-€ 2,218,605.65	-19.89%
250%	2%	-€ 745,292.17	5.07%
250%	50%	-€ 1,372,183.67	-5.54%
250%	100%	-€ 2,025,195.64	-16.58%
250%	150%	-€ 2,678,207.62	-27.93%

Table 94: Case 1 – Energy and Path Costs Sensitivity Analysis, All Combinations

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 2,733,894.68**	**73.45%**
60.75%	50%	**€ 2,107,003.19**	**59.16%**
60.75%	100%	**€ 1,453,991.21**	**45.44%**
60.75%	150%	€ 800,979.24	32.68%
75%	2%	**€ 2,471,921.57**	**67.33%**
75%	50%	**€ 1,845,030.07**	**53.52%**
75%	100%	**€ 1,192,018.09**	**40.22%**
75%	150%	€ 539,006.12	27.79%
100%	2%	**€ 2,012,319.60**	**57.10%**
100%	50%	**€ 1,385,428.11**	**44.06%**
100%	100%	€ 732,416.13	31.39%
100%	150%	€ 79,404.16	19.44%
125%	2%	**€ 1,552,717.64**	**47.45%**
125%	50%	€ 925,826.15	35.06%
125%	100%	€ 272,814.17	22.92%
150%	2%	**€ 1,093,115.68**	**38.29%**
150%	50%	€ 466,224.18	26.45%
175%	2%	€ 633,513.72	29.54%
175%	50%	€ 6,622.22	18.15%
200%	2%	€ 173,911.76	21.14%

Table 95: Case 1 – Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.2 Case 2 – Energy and Path Costs Sensitivity Analysis

There were instances of profitability observed over the range of factors for Kw and paths. This is consistent with the financial analysis of scenario Case 2 in analyzing the parameters of load factor, wagons per train and rate per km, covered in **Section 6.3.3 Case 2 - Antwerp – Wroclaw**.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 2,538,391.87**	**70.76%**
60.75%	50%	**€ 1,646,405.60**	**49.98%**
60.75%	100%	€ 717,253.23	31.11%
60.75%	150%	-€ 211,899.14	14.37%
75%	2%	**€ 2,311,281.63**	**65.31%**
75%	50%	**€ 1,419,295.36**	**45.21%**
75%	100%	€ 490,142.99	26.87%
75%	150%	-€ 439,009.38	10.51%
100%	2%	**€ 1,912,842.62**	**56.17%**
100%	50%	**€ 1,020,856.35**	**37.16%**
100%	100%	€ 91,703.98	19.65%
100%	150%	-€ 837,448.39	3.89%
125%	2%	**€ 1,514,403.61**	**47.52%**
125%	50%	**€ 622,417.33**	**29.46%**
125%	100%	-€ 306,735.04	12.68%
125%	150%	-€ 1,235,887.40	-2.58%
150%	2%	**€ 1,115,964.59**	**39.28%**
150%	50%	€ 223,978.32	22.07%
150%	100%	-€ 705,174.05	5.92%
150%	150%	-€ 1,634,326.42	-8.93%
175%	2%	€ 717,525.58	31.42%
175%	50%	-€ 174,460.69	14.94%
175%	100%	-€ 1,103,613.06	-0.69%
175%	150%	-€ 2,032,765.43	-15.21%
200%	2%	€ 319,086.57	23.88%
200%	50%	-€ 572,899.71	8.02%
200%	100%	-€ 1,502,052.08	-7.17%
200%	150%	-€ 2,431,204.44	-21.46%
225%	2%	-€ 79,352.45	16.60%
225%	50%	-€ 971,338.72	1.27%
225%	100%	-€ 1,900,491.09	-13.58%
225%	150%	-€ 2,831,518.24	-27.81%
250%	2%	-€ 477,791.46	9.55%

250%	**50%**	-€ 1,369,777.73	-5.35%
250%	**100%**	-€ 2,298,930.10	-19.95%
250%	**150%**	-€ 3,269,488.86	-35.65%

Table 96: Case 2 – Energy and Path Costs Sensitivity Analysis, All Combinations

Table 97 shows the profitable scenario factor combinations for Case 2.

kW Factor	Path Factor	NPV	IRR
60.75%	**2%**	**€ 2,538,391.87**	**70.76%**
60.75%	**50%**	**€ 1,646,405.60**	**49.98%**
60.75%	**100%**	€ 717,253.23	31.11%
75%	**2%**	**€ 2,311,281.63**	**65.31%**
75%	**50%**	**€ 1,419,295.36**	**45.21%**
75%	**100%**	€ 490,142.99	26.87%
100%	**2%**	**€ 1,912,842.62**	**56.17%**
100%	**50%**	**€ 1,020,856.35**	**37.16%**
100%	**100%**	€ 91,703.98	19.65%
125%	**2%**	**€ 1,514,403.61**	**47.52%**
125%	**50%**	€ 622,417.33	29.46%
150%	**2%**	**€ 1,115,964.59**	**39.28%**
150%	**50%**	€ 223,978.32	22.07%
175%	**2%**	€ 717,525.58	31.42%
200%	**2%**	€ 319,086.57	23.88%

Table 97: Case 2 – Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.3 Case 3 – Energy and Path Costs Sensitivity Analysis

Scenario Case 3 retains profitability up to 250% of kW base costs, but only 2% of path costs.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**3,190,356.59**	**85.19%**
60.75%	50%	**2,563,465.09**	**69.77%**
60.75%	100%	**1,910,453.12**	**55.12%**
60.75%	150%	**1,257,441.14**	**41.62%**
75%	2%	**2,928,613.88**	**78.57%**
75%	50%	**2,301,722.39**	**63.74%**
75%	100%	**1,648,710.41**	**49.58%**
75%	150%	995,698.44	36.48%
100%	2%	**2,469,416.16**	**67.57%**
100%	50%	**1,842,524.66**	**53.66%**
100%	100%	**1,189,512.69**	**40.27%**
100%	150%	536,500.71	27.78%
125%	2%	**2,010,218.43**	**57.27%**
125%	50%	**1,383,326.94**	**44.14%**
125%	100%	730,314.96	31.41%
125%	150%	77,302.99	19.41%
150%	2%	**1,551,020.71**	**47.56%**
150%	50%	924,129.21	35.10%
150%	100%	271,117.24	22.91%
150%	150%	-381,894.74	11.31%
175%	2%	**1,091,822.98**	**38.35%**
175%	50%	464,931.49	26.45%
175%	100%	-188,080.49	14.70%
175%	150%	-841,092.46	3.41%
200%	2%	632,625.26	29.57%
200%	50%	5,733.76	18.13%
200%	100%	-647,278.21	6.73%
200%	150%	-1,300,290.19	-4.36%
225%	2%	173,427.53	21.14%
225%	50%	-453,463.96	10.07%
225%	100%	-1,106,475.94	-1.09%
225%	150%	-1,759,487.91	-12.09%
250%	2%	-285,770.19	12.99%
250%	50%	-912,661.69	2.20%

250%	100%	-1,565,673.66	-8.83%
250%	150%	-2,218,685.64	-19.88%

Table 98: Case 3 – Energy and Path Costs Sensitivity Analysis, All Combinations

Table 99 shows the profitable scenario factor combinations for Case 3.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**3,190,356.59**	**85.19%**
60.75%	50%	**2,563,465.09**	**69.77%**
60.75%	100%	**1,910,453.12**	**55.12%**
60.75%	150%	**1,257,441.14**	**41.62%**
75%	2%	**2,928,613.88**	**78.57%**
75%	50%	**2,301,722.39**	**63.74%**
75%	100%	**1,648,710.41**	**49.58%**
75%	150%	995,698.44	36.48%
100%	2%	**2,469,416.16**	**67.57%**
100%	50%	**1,842,524.66**	**53.66%**
100%	100%	**1,189,512.69**	**40.27%**
100%	150%	536,500.71	27.78%
125%	2%	**2,010,218.43**	**57.27%**
125%	50%	**1,383,326.94**	**44.14%**
125%	100%	730,314.96	31.41%
125%	150%	77,302.99	19.41%
150%	2%	**1,551,020.71**	**47.56%**
150%	50%	924,129.21	35.10%
150%	100%	271,117.24	22.91%
175%	2%	**1,091,822.98**	**38.35%**
175%	50%	464,931.49	26.45%
200%	2%	632,625.26	29.57%
200%	50%	5,733.76	18.13%
225%	2%	173,427.53	21.14%

Table 99: Case 3 – Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.4 Case 4– Energy and Path Costs Sensitivity Analysis

Case 4 makes profit over a smaller range.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	€ 3,071,836.54	80.16%
60.75%	50%	€ 2,095,749.82	57.97%
60.75%	100%	€ 1,078,992.81	37.57%
60.75%	150%	€ 62,235.80	19.11%
75%	2%	€ 2,835,631.89	74.51%
75%	50%	€ 1,859,545.17	53.02%
75%	100%	€ 842,788.16	33.14%
75%	150%	-€ 173,968.85	15.03%
100%	2%	€ 2,421,237.77	65.04%
100%	50%	€ 1,445,151.05	44.65%
100%	100%	€ 428,394.04	25.58%
100%	150%	-€ 588,362.97	7.99%
125%	2%	€ 2,006,843.65	56.09%
125%	50%	€ 1,030,756.93	36.66%
125%	100%	€ 13,999.92	18.27%
125%	150%	-€ 1,002,757.09	1.08%
150%	2%	€ 1,592,449.53	47.58%
150%	50%	€ 616,362.81	28.98%
150%	100%	-€ 400,394.20	11.16%
150%	150%	-€ 1,417,151.21	-5.76%
175%	2%	€ 1,178,055.41	39.46%
175%	50%	€ 201,968.69	21.56%
175%	100%	-€ 814,788.32	4.20%
175%	150%	-€ 1,831,545.33	-12.58%
200%	2%	€ 763,661.29	31.67%
200%	50%	-€ 212,425.43	14.37%
200%	100%	-€ 1,229,182.44	-2.67%
200%	150%	-€ 2,245,939.45	-19.45%
225%	2%	€ 349,267.17	24.17%
225%	50%	-€ 626,819.55	7.34%
225%	100%	-€ 1,643,576.56	-9.48%
225%	150%	-€ 2,660,333.57	-26.48%
250%	2%	-€ 65,126.94	16.90%

250%	50%	-€ 1,041,213.67	0.44%
250%	100%	-€ 2,057,970.68	-16.32%
250%	150%	-€ 3,074,727.69	-33.80%

Table 100: Case 4 – Energy and Path Costs Sensitivity Analysis, All Combinations

Table 101 shows the profitable scenario factor combinations for Case 4.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	€ 3,071,836.54	80.16%
60.75%	50%	€ 2,095,749.82	57.97%
60.75%	100%	€ 1,078,992.81	37.57%
60.75%	150%	€ 62,235.80	19.11%
75%	2%	€ 2,835,631.89	74.51%
75%	50%	€ 1,859,545.17	53.02%
75%	100%	€ 842,788.16	33.14%
100%	2%	€ 2,421,237.77	65.04%
100%	50%	€ 1,445,151.05	44.65%
100%	100%	€ 428,394.04	25.58%
125%	2%	€ 2,006,843.65	56.09%
125%	50%	€ 1,030,756.93	36.66%
125%	100%	€ 13,999.92	18.27%
150%	2%	€ 1,592,449.53	47.58%
150%	50%	€ 616,362.81	28.98%
175%	2%	€ 1,178,055.41	39.46%
175%	50%	€ 201,968.69	21.56%
200%	2%	€ 763,661.29	31.67%
225%	2%	€ 349,267.17	24.17%

Table 101: Case 4– Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.5 Case 5– Energy and Path Costs Sensitivity Analysis

Case 5 has a partial truck segment to and from Poland from the border in Germany. This affects the rail portions measured, because the cost impact is spread over a smaller portion of rail segments.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**2,267,304.93**	**55.62%**
60.75%	50%	**1,588,968.64**	**43.60%**
60.75%	100%	882,368.35	31.85%
60.75%	150%	175,768.05	20.72%
75%	2%	**1,961,808.95**	**50.10%**
75%	50%	**1,283,472.66**	**38.43%**
75%	100%	576,872.37	26.97%
75%	150%	-129,727.93	16.06%
100%	2%	**1,425,851.09**	**40.82%**
100%	50%	747,514.81	29.68%
100%	100%	40,914.51	18.65%
100%	150%	-665,685.79	8.05%
125%	2%	889,893.24	31.97%
125%	50%	211,556.95	21.27%
125%	100%	-495,043.34	10.58%
125%	150%	-1,201,643.64	0.20%
150%	2%	353,935.38	23.48%
150%	50%	-324,400.90	13.13%
150%	100%	-1,031,001.20	2.69%
150%	150%	-1,737,601.50	-7.57%
175%	2%	-182,022.48	15.27%
175%	50%	-860,358.76	5.19%
175%	100%	-1,566,959.06	-5.10%
175%	150%	-2,273,559.35	-15.37%
200%	2%	-717,980.33	7.28%
200%	50%	-1,396,316.62	-2.63%
200%	100%	-2,102,916.91	-12.88%
200%	150%	-2,809,517.21	-23.30%
225%	2%	-1,253,938.19	-0.56%
225%	50%	-1,932,274.47	-10.40%
225%	100%	-2,638,874.77	-20.75%

225%	150%	-3,345,475.07	-31.55%
250%	2%	-1,789,896.04	-8.33%
250%	50%	-2,468,232.33	-18.23%
250%	100%	-3,174,832.63	-28.88%
250%	150%	-3,881,432.92	-40.41%

Table 102: Case 5 – Energy and Path Costs Sensitivity Analysis, All Combinations

Table 103 shows the only profitable scenario factor combination for Case 5.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**2,267,304.93**	**55.62%**
60.75%	50%	**1,588,968.64**	**43.60%**
60.75%	100%	882,368.35	31.85%
60.75%	150%	175,768.05	20.72%
75%	2%	**1,961,808.95**	**50.10%**
75%	50%	**1,283,472.66**	**38.43%**
75%	100%	576,872.37	26.97%
100%	2%	**1,425,851.09**	**40.82%**
100%	50%	747,514.81	29.68%
100%	100%	40,914.51	18.65%
125%	2%	889,893.24	31.97%
125%	50%	211,556.95	21.27%
125%	100%	-495,043.34	10.58%
150%	2%	353,935.38	23.48%

Table 103: Case 5– Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.6 Case 6– Energy and Path Costs Sensitivity Analysis

Case 6 shows a much smaller range of profitable scenarios from the kW and path factors from the more closely related Cases 5, 7 and 8.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 2,022,555.37**	**49.20%**
60.75%	50%	**€ 1,165,264.71**	**35.41%**
60.75%	100%	€ 272,253.61	21.98%
60.75%	150%	-€ 620,757.49	9.23%
75%	2%	**€ 1,629,008.40**	**42.74%**
75%	50%	€ 771,717.75	29.38%
75%	100%	-€ 121,293.35	16.29%
75%	150%	-€ 1,014,304.45	3.77%
100%	2%	€ 938,575.13	31.92%
100%	50%	€ 81,284.47	19.20%
100%	100%	-€ 811,726.63	6.57%
100%	150%	-€ 1,704,737.73	-5.70%
125%	2%	€ 248,141.86	21.62%
125%	50%	-€ 609,148.80	9.40%
125%	100%	-€ 1,502,159.90	-2.93%
125%	150%	-€ 2,395,171.00	-15.15%
150%	2%	-€ 442,291.42	11.74%
150%	50%	-€ 1,299,582.08	-0.16%
150%	100%	-€ 2,192,593.18	-12.37%
150%	150%	-€ 3,085,604.28	-24.80%
175%	2%	-€ 1,132,724.69	2.14%
175%	50%	-€ 1,990,015.35	-9.60%
175%	100%	-€ 2,883,026.45	-21.93%
175%	150%	-€ 3,776,037.55	-34.96%
200%	2%	-€ 1,823,157.97	-7.32%
200%	50%	-€ 2,680,448.62	-19.10%
200%	100%	-€ 3,573,459.72	-31.90%
200%	150%	-€ 4,466,470.83	-46.28%
225%	2%	-€ 2,513,591.24	-16.79%
225%	50%	-€ 3,370,881.90	-28.91%
225%	100%	-€ 4,263,893.00	-42.77%
225%	150%	-€ 5,156,904.10	-60.51%

250%	**2%**	-€ 3,204,024.52	-26.49%
250%	**50%**	-€ 4,061,315.17	-39.44%
250%	**100%**	-€ 4,954,326.27	-55.79%
250%	**150%**	-€ 5,857,911.43	**N/A**

Table 104: Case 6 – Energy and Path Costs Sensitivity Analysis, All Combinations

With Case 6, are the range combinations of kW and path factors that are profitable.

kW Factor	Path Factor	NPV	IRR
60.75%	**2%**	**€ 2,022,555.37**	**49.20%**
60.75%	**50%**	**€ 1,165,264.71**	**35.41%**
60.75%	**100%**	€ 272,253.61	21.98%
75%	**2%**	**€ 1,629,008.40**	**42.74%**
75%	**50%**	€ 771,717.75	29.38%
100%	**2%**	€ 938,575.13	31.92%
100%	**50%**	€ 81,284.47	19.20%
125%	**2%**	€ 248,141.86	21.62%

Table 105: Case 6– Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.7 Case 7– Energy and Path Costs Sensitivity Analysis

Case 6 shows a slightly higher range of profitable scenarios from the kW and path factors from Case 7 and 8, but not as wide a range as Case 5.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 2,217,488.64**	**53.55%**
60.75%	50%	**€ 1,366,309.76**	**39.15%**
60.75%	100%	€ 479,665.10	25.22%
60.75%	150%	-€ 406,979.57	12.08%
75%	2%	**€ 1,826,747.34**	**46.80%**
75%	50%	€ 975,568.46	32.89%
75%	100%	€ 88,923.80	19.35%
75%	150%	-€ 797,720.87	6.47%
100%	2%	**€ 1,141,236.29**	**35.52%**
100%	50%	€ 290,057.41	22.35%
100%	100%	-€ 596,587.25	9.35%
100%	150%	-€ 1,483,231.92	-3.21%
125%	2%	€ 455,725.24	24.85%
125%	50%	-€ 395,453.64	12.25%
125%	100%	-€ 1,282,098.31	-0.38%
125%	150%	-€ 2,168,742.97	-12.83%
150%	2%	-€ 229,785.81	14.66%
150%	50%	-€ 1,080,964.69	2.45%
150%	100%	-€ 1,967,609.36	-10.00%
150%	150%	-€ 2,854,254.02	-22.59%
175%	2%	-€ 915,296.87	4.80%
175%	50%	-€ 1,766,475.74	-7.18%
175%	100%	-€ 2,653,120.41	-19.69%
175%	150%	-€ 3,539,765.07	-32.80%
200%	2%	-€ 1,600,807.92	-4.86%
200%	50%	-€ 2,451,986.80	-16.83%
200%	100%	-€ 3,338,631.46	-29.73%
200%	150%	-€ 4,225,276.13	-44.07%
225%	2%	-€ 2,286,318.97	-14.48%
225%	50%	-€ 3,137,497.85	-26.73%
225%	100%	-€ 4,024,142.51	-40.60%
225%	150%	-€ 4,910,787.18	-57.97%

250%	**2%**	-€ 2,971,830.02	-24.29%
250%	**50%**	-€ 3,823,008.90	-37.28%
250%	**100%**	-€ 4,709,653.57	-53.41%
250%	**150%**	-€ 5,604,595.51	**N/A**

Table 106: Case 7 – Energy and Path Costs Sensitivity Analysis, All Combinations

With Case 7, below are the range combinations of kW and path factors that are profitable.

kW Factor	Path Factor	NPV	IRR
60.75%	**2%**	**€ 2,217,488.64**	**53.55%**
60.75%	**50%**	**€ 1,366,309.76**	**39.15%**
60.75%	**100%**	€ 479,665.10	25.22%
75%	**2%**	**€ 1,826,747.34**	**46.80%**
75%	**50%**	€ 975,568.46	32.89%
75%	**100%**	€ 88,923.80	19.35%
100%	**2%**	**€ 1,141,236.29**	**35.52%**
100%	**50%**	€ 290,057.41	22.35%
125%	**2%**	€ 455,725.24	24.85%

Table 107: Case 7– Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.8 Case 8– Energy and Path Costs Sensitivity Analysis

Scenario case 8 adds another combination of 150% kW factor, but only at the 2% path factor.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 1,756,556.74**	**47.74%**
60.75%	50%	**€ 1,078,220.46**	**35.75%**
60.75%	100%	€ 371,620.16	23.99%
60.75%	150%	-€ 334,980.13	12.77%
75%	2%	**€ 1,451,060.77**	**42.25%**
75%	50%	€ 772,724.48	30.59%
75%	100%	€ 66,124.18	19.08%
75%	150%	-€ 640,476.11	8.05%
100%	2%	€ 915,102.91	32.98%
100%	50%	€ 236,766.63	21.81%
100%	100%	-€ 469,833.67	10.68%
100%	150%	-€ 1,176,433.97	-0.12%
125%	2%	€ 379,145.05	24.11%
125%	50%	-€ 299,191.23	13.33%
125%	100%	-€ 1,005,791.53	2.47%
125%	150%	-€ 1,712,391.82	-8.20%
150%	2%	-€ 156,812.80	15.56%
150%	50%	-€ 835,149.09	5.07%
150%	100%	-€ 1,541,749.38	-5.63%
150%	150%	-€ 2,248,349.68	-16.31%
175%	2%	-€ 692,770.66	7.25%
175%	50%	-€ 1,371,106.94	-3.06%
175%	100%	-€ 2,077,707.24	-13.72%
175%	150%	-€ 2,784,307.54	-24.59%
200%	2%	-€ 1,228,728.51	-0.91%
200%	50%	-€ 1,907,064.80	-11.14%
200%	100%	-€ 2,613,665.10	-21.92%
200%	150%	-€ 3,320,265.39	-33.25%
225%	2%	-€ 1,764,686.37	-8.99%
225%	50%	-€ 2,443,022.66	-19.29%
225%	100%	-€ 3,149,622.95	-30.44%
225%	150%	-€ 3,856,223.25	-42.67%
250%	2%	-€ 2,300,644.23	-17.11%

250%	50%	-€ 2,978,980.51	-27.68%
250%	100%	-€ 3,685,580.81	-39.55%
250%	150%	-€ 4,392,181.10	-53.67%

Table 108: Case 7 – Energy and Path Costs Sensitivity Analysis, All Combinations

With Case 8, there are no combinations in which the range of kW and path factors are profitable.

The factor combinations are small and like Case 7, albeit without the same financial performance.

kW Factor	Path Factor	NPV	IRR
60.75%	2%	**€ 1,756,556.74**	**47.74%**
60.75%	50%	**€ 1,078,220.46**	**35.75%**
60.75%	100%	€ 371,620.16	23.99%
75%	2%	**€ 1,451,060.77**	**42.25%**
75%	50%	€ 772,724.48	30.59%
75%	100%	€ 66,124.18	19.08%
100%	2%	€ 915,102.91	32.98%
100%	50%	€ 236,766.63	21.81%
125%	2%	€ 379,145.05	24.11%

Table 109: Case 8– Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit

6.8.9.1 Cases 1 – 4, Energy and Path Costs Sensitivity Analysis

The following pages show the overview of scenario cases 1 – 4 and their respective financial performance by kW and path factors.

		Case 1		Case 2		Case 3		Case 4	
kW Factor	**Path Factor**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**
60.75%	2%	**€ 2,733,894.68**	**73.45%**	**€ 2,538,391.87**	**70.76%**	**3,190,356.59**	**85.19%**	**3,071,836.54**	**80.16%**
60.75%	50%	**€ 2,107,003.19**	**59.16%**	**€ 1,646,405.60**	**49.98%**	**2,563,465.09**	**69.77%**	**2,095,749.82**	**57.97%**
60.75%	100%	**€ 1,453,991.21**	**45.44%**	€ 717,253.23	31.11%	**1,910,453.12**	**55.12%**	**1,078,992.81**	**37.57%**
60.75%	150%	€ 800,979.24	32.68%	-€ 211,899.14	14.37%	**1,257,441.14**	**41.62%**	62,235.80	19.11%
75%	2%	**€ 2,471,921.57**	**67.33%**	**€ 2,311,281.63**	**65.31%**	**2,928,613.88**	**78.57%**	**2,835,631.89**	**74.51%**
75%	50%	**€ 1,845,030.07**	**53.52%**	**€ 1,419,295.36**	**45.21%**	**2,301,722.39**	**63.74%**	**1,859,545.17**	**53.02%**
75%	100%	**€ 1,192,018.09**	**40.22%**	€ 490,142.99	26.87%	**1,648,710.41**	**49.58%**	842,788.16	33.14%
75%	150%	€ 539,006.12	27.79%	-€ 439,009.38	10.51%	995,698.44	36.48%	-173,968.85	15.03%
100%	2%	**€ 2,012,319.60**	**57.10%**	**€ 1,912,842.62**	**56.17%**	**2,469,416.16**	**67.57%**	**2,421,237.77**	**65.04%**
100%	50%	**€ 1,385,428.11**	**44.06%**	**€ 1,020,856.35**	**37.16%**	**1,842,524.66**	**53.66%**	**1,445,151.05**	**44.65%**
100%	100%	€ 732,416.13	31.39%	€ 91,703.98	19.65%	**1,189,512.69**	**40.27%**	428,394.04	25.58%
100%	150%	€ 79,404.16	19.44%	-€ 837,448.39	3.89%	536,500.71	27.78%	-588,362.97	7.99%
125%	2%	**€ 1,552,717.64**	**47.45%**	**€ 1,514,403.61**	**47.52%**	**2,010,218.43**	**57.27%**	**2,006,843.65**	**56.09%**
125%	50%	€ 925,826.15	35.06%	€ 622,417.33	29.46%	**1,383,326.94**	**44.14%**	**1,030,756.93**	**36.66%**
125%	100%	€ 272,814.17	22.92%	-€ 306,735.04	12.68%	730,314.96	31.41%	13,999.92	18.27%
125%	150%	-€ 380,197.81	11.36%	-€ 1,235,887.40	-2.58%	77,302.99	19.41%	-1,002,757.09	1.08%
150%	2%	**€ 1,093,115.68**	**38.29%**	**€ 1,115,964.59**	**39.28%**	**1,551,020.71**	**47.56%**	**1,592,449.53**	**47.58%**
150%	50%	€ 466,224.18	26.45%	€ 223,978.32	22.07%	924,129.21	35.10%	616,362.81	28.98%
150%	100%	-€ 186,787.79	14.73%	-€ 705,174.05	5.92%	271,117.24	22.91%	-400,394.20	11.16%
150%	150%	-€ 839,799.77	3.46%	-€ 1,634,326.42	-8.93%	-381,894.74	11.31%	-1,417,151.21	-5.76%

Table 110: Cases 1 – 4, Energy and Path Costs Sensitivity Analysis

		Case 1		Case 2		Case 3		Case 4	
kW Factor	**Path Factor**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**
175%	2%	€ 633,513.72	29.54%	€ 717,525.58	31.42%	**1,091,822.98**	**38.35%**	**1,178,055.41**	**39.46%**
175%	50%	€ 6,622.22	18.15%	-€ 174,460.69	14.94%	464,931.49	26.45%	201,968.69	21.56%
175%	100%	-€ 646,389.75	6.77%	-€ 1,103,613.06	-0.69%	-188,080.49	14.70%	-814,788.32	4.20%
175%	150%	-€ 1,299,401.73	-4.32%	-€ 2,032,765.43	-15.21%	-841,092.46	3.41%	-1,831,545.33	-12.58%
200%	2%	€ 173,911.76	21.14%	€ 319,086.57	23.88%	632,625.26	29.57%	763,661.29	31.67%
200%	50%	-€ 452,979.74	10.10%	-€ 572,899.71	8.02%	5,733.76	18.13%	-212,425.43	14.37%
200%	100%	-€ 1,105,991.72	-1.05%	-€ 1,502,052.08	-7.17%	-647,278.21	6.73%	-1,229,182.44	-2.67%
200%	150%	-€ 1,759,003.69	-12.07%	-€ 2,431,204.44	-21.46%	-1,300,290.19	-4.36%	-2,245,939.45	-19.45%
225%	2%	-€ 285,690.21	13.00%	-€ 79,352.45	16.60%	173,427.53	21.14%	349,267.17	24.17%
225%	50%	-€ 912,581.70	2.23%	-€ 971,338.72	1.27%	-453,463.96	10.07%	-626,819.55	7.34%
225%	100%	-€ 1,565,593.68	-8.80%	-€ 1,900,491.09	-13.58%	-1,106,475.94	-1.09%	-1,643,576.56	-9.48%
225%	150%	-€ 2,218,605.65	-19.89%	-€ 2,831,518.24	-27.81%	-1,759,487.91	-12.09%	-2,660,333.57	-26.48%
250%	2%	-€ 745,292.17	5.07%	-€ 477,791.46	9.55%	-285,770.19	12.99%	-65,126.94	16.90%
250%	50%	-€ 1,372,183.67	-5.54%	-€ 1,369,777.73	-5.35%	-912,661.69	2.20%	-1,041,213.67	0.44%
250%	100%	-€ 2,025,195.64	-16.58%	-€ 2,298,930.10	-19.95%	-1,565,673.66	-8.83%	-2,057,970.68	-16.32%
250%	150%	-€ 2,678,207.62	-27.93%	-€ 3,269,488.86	-35.65%	-2,218,685.64	-19.88%	-3,074,727.69	-33.80%

6.8.9.2 Cases 5 – 8, Energy and Path Costs Sensitivity Analysis

The following pages show the overview of scenario cases 5 – 8 and their respective financial performance by kW and path factors.

		Case 5		Case 6		Case 7		Case 8	
kW Factor	**Path Factor**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**
60.75%	2%	**2,267,304.93**	**55.62%**	**€ 2,022,555.37**	**49.20%**	**€ 2,217,488.64**	**53.55%**	**€ 1,756,556.74**	**47.74%**
60.75%	50%	**1,588,968.64**	**43.60%**	**€ 1,165,264.71**	**35.41%**	**€ 1,366,309.76**	**39.15%**	**€ 1,078,220.46**	**35.75%**
60.75%	100%	882,368.35	31.85%	€ 272,253.61	21.98%	€ 479,665.10	25.22%	€ 371,620.16	23.99%
60.75%	150%	175,768.05	20.72%	-€ 620,757.49	9.23%	-€ 406,979.57	12.08%	-€ 334,980.13	12.77%
75%	2%	**1,961,808.95**	**50.10%**	**€ 1,629,008.40**	**42.74%**	**€ 1,826,747.34**	**46.80%**	**€ 1,451,060.77**	**42.25%**
75%	50%	**1,283,472.66**	**38.43%**	€ 771,717.75	29.38%	€ 975,568.46	32.89%	€ 772,724.48	30.59%
75%	100%	576,872.37	26.97%	-€ 121,293.35	16.29%	€ 88,923.80	19.35%	€ 66,124.18	19.08%
75%	150%	-129,727.93	16.06%	-€ 1,014,304.45	3.77%	-€ 797,720.87	6.47%	-€ 640,476.11	8.05%
100%	2%	**1,425,851.09**	**40.82%**	€ 938,575.13	31.92%	**€ 1,141,236.29**	**35.52%**	€ 915,102.91	32.98%
100%	50%	747,514.81	29.68%	€ 81,284.47	19.20%	€ 290,057.41	22.35%	€ 236,766.63	21.81%
100%	100%	40,914.51	18.65%	-€ 811,726.63	6.57%	-€ 596,587.25	9.35%	-€ 469,833.67	10.68%
100%	150%	-665,685.79	8.05%	-€ 1,704,737.73	-5.70%	-€ 1,483,231.92	-3.21%	-€ 1,176,433.97	-0.12%
125%	2%	889,893.24	31.97%	€ 248,141.86	21.62%	€ 455,725.24	24.85%	€ 379,145.05	24.11%
125%	50%	211,556.95	21.27%	-€ 609,148.80	9.40%	-€ 395,453.64	12.25%	-€ 299,191.23	13.33%
125%	100%	-495,043.34	10.58%	-€ 1,502,159.90	-2.93%	-€ 1,282,098.31	-0.38%	-€ 1,005,791.53	2.47%
125%	150%	-1,201,643.64	0.20%	-€ 2,395,171.00	-15.15%	-€ 2,168,742.97	-12.83%	-€ 1,712,391.82	-8.20%
150%	2%	353,935.38	23.48%	-€ 442,291.42	11.74%	-€ 229,785.81	14.66%	-€ 156,812.80	15.56%
150%	50%	-324,400.90	13.13%	-€ 1,299,582.08	-0.16%	-€ 1,080,964.69	2.45%	-€ 835,149.09	5.07%
150%	100%	-1,031,001.20	2.69%	-€ 2,192,593.18	-12.37%	-€ 1,967,609.36	-10.00%	-€ 1,541,749.38	-5.63%
150%	150%	-1,737,601.50	-7.57%	-€ 3,085,604.28	-24.80%	-€ 2,854,254.02	-22.59%	-€ 2,248,349.68	-16.31%

Table 111: Cases 5 – 8, Energy and Path Costs Sensitivity Analysis

		Case 5		Case 6		Case 7		Case 8	
kW Factor	Path Factor	NPV	IRR	NPV	IRR	NPV	IRR	NPV	IRR
175%	2%	-182,022.48	15.27%	-€ 1,132,724.69	2.14%	-€ 915,296.87	4.80%	-€ 692,770.66	7.25%
175%	50%	-860,358.76	5.19%	-€ 1,990,015.35	-9.60%	-€ 1,766,475.74	-7.18%	-€ 1,371,106.94	-3.06%
175%	100%	-1,566,959.06	-5.10%	-€ 2,883,026.45	-21.93%	-€ 2,653,120.41	-19.69%	-€ 2,077,707.24	-13.72%
175%	150%	-2,273,559.35	-15.37%	-€ 3,776,037.55	-34.96%	-€ 3,539,765.07	-32.80%	-€ 2,784,307.54	-24.59%
200%	2%	-717,980.33	7.28%	-€ 1,823,157.97	-7.32%	-€ 1,600,807.92	-4.86%	-€ 1,228,728.51	-0.91%
200%	50%	-1,396,316.62	-2.63%	-€ 2,680,448.62	-19.10%	-€ 2,451,986.80	-16.83%	-€ 1,907,064.80	-11.14%
200%	100%	-2,102,916.91	-12.88%	-€ 3,573,459.72	-31.90%	-€ 3,338,631.46	-29.73%	-€ 2,613,665.10	-21.92%
200%	150%	-2,809,517.21	-23.30%	-€ 4,466,470.83	-46.28%	-€ 4,225,276.13	-44.07%	-€ 3,320,265.39	-33.25%
225%	2%	-1,253,938.19	-0.56%	-€ 2,513,591.24	-16.79%	-€ 2,286,318.97	-14.48%	-€ 1,764,686.37	-8.99%
225%	50%	-1,932,274.47	-10.40%	-€ 3,370,881.90	-28.91%	-€ 3,137,497.85	-26.73%	-€ 2,443,022.66	-19.29%
225%	100%	-2,638,874.77	-20.75%	-€ 4,263,893.00	-42.77%	-€ 4,024,142.51	-40.60%	-€ 3,149,622.95	-30.44%
225%	150%	-3,345,475.07	-31.55%	-€ 5,156,904.10	-60.51%	-€ 4,910,787.18	-57.97%	-€ 3,856,223.25	-42.67%
250%	2%	-1,789,896.04	-8.33%	-€ 3,204,024.52	-26.49%	-€ 2,971,830.02	-24.29%	-€ 2,300,644.23	-17.11%
250%	50%	-2,468,232.33	-18.23%	-€ 4,061,315.17	-39.44%	-€ 3,823,008.90	-37.28%	-€ 2,978,980.51	-27.68%
250%	100%	-3,174,832.63	-28.88%	-€ 4,954,326.27	-55.79%	-€ 4,709,653.57	-53.41%	-€ 3,685,580.81	-39.55%
250%	150%	-3,881,432.92	-40.41%	-€ 5,857,911.43	N/A	-€ 5,604,595.51	N/A	-€ 4,392,181.10	-53.67%

6.8.9.3 Summary Conclusions on Sensitivity Analysis of Two Cost Variables

Closer analysis of the proportion of major cost categories that energy and path represent illustrates the impact the change of these costs categories have on NPV and IRR values. Further below are the two separate sets of Cases, 1 – 4 and 5 – 8, analyzed separately within their respective set categories. Sets 1 – 4 are transport by rail only and Sets 5 – 8 uses rail initially and then truck for the final short segment to/from Poland.

In Case 3, path costs are substantially higher than in Cases 1, 2 and 4, making that category more sensitive to reduction in costs. For Case 4, energy costs are higher than in Cases 1 – 3, so it follows that a reduction in energy costs would have the most effect on NPV and IRR values and therefore, increased sensitivity to variations in value.

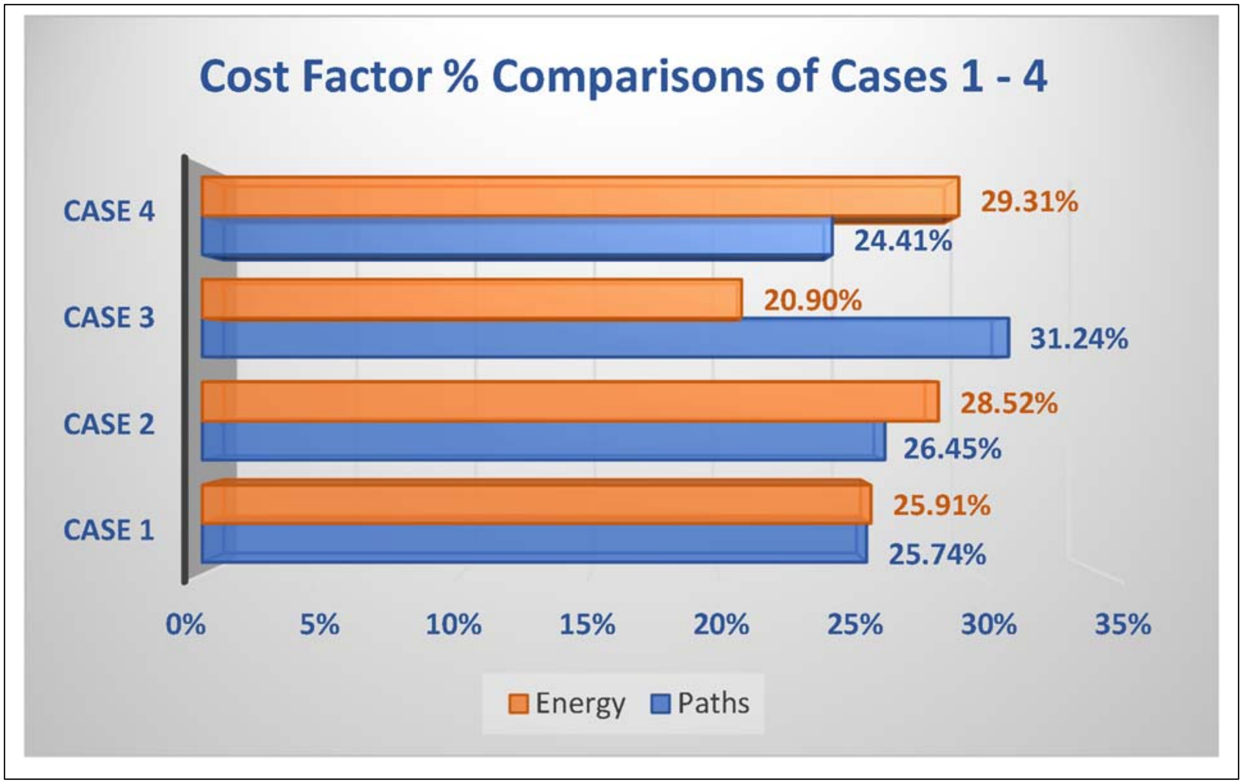

Figure 59: Cost Factor % Comparisons Cases 1 - 4

With Cases 5 – 8 with the trucking component, ostensibly, Case 5 seems the least sensitive to energy and path cost increases. In Case 5, however, the path cost proportion of expenses exceeds those of Cases 6, 7 and 8. (See **Figure 55**). Because the trucking cost proportion of Case 5 also exceeds the proportion of costs of Cases 6, 7 and 8, a reduction in path costs has a positive and amplified effect on overall costs of Case 5, improving its profitability to the point that of the four cases with truck segments, it ranks first in profitability and of all eight cases, it ranks fourth. Expressed differently, these means that path costs have a greater sensitivity and impact on NPV and IRR values for Case 5.

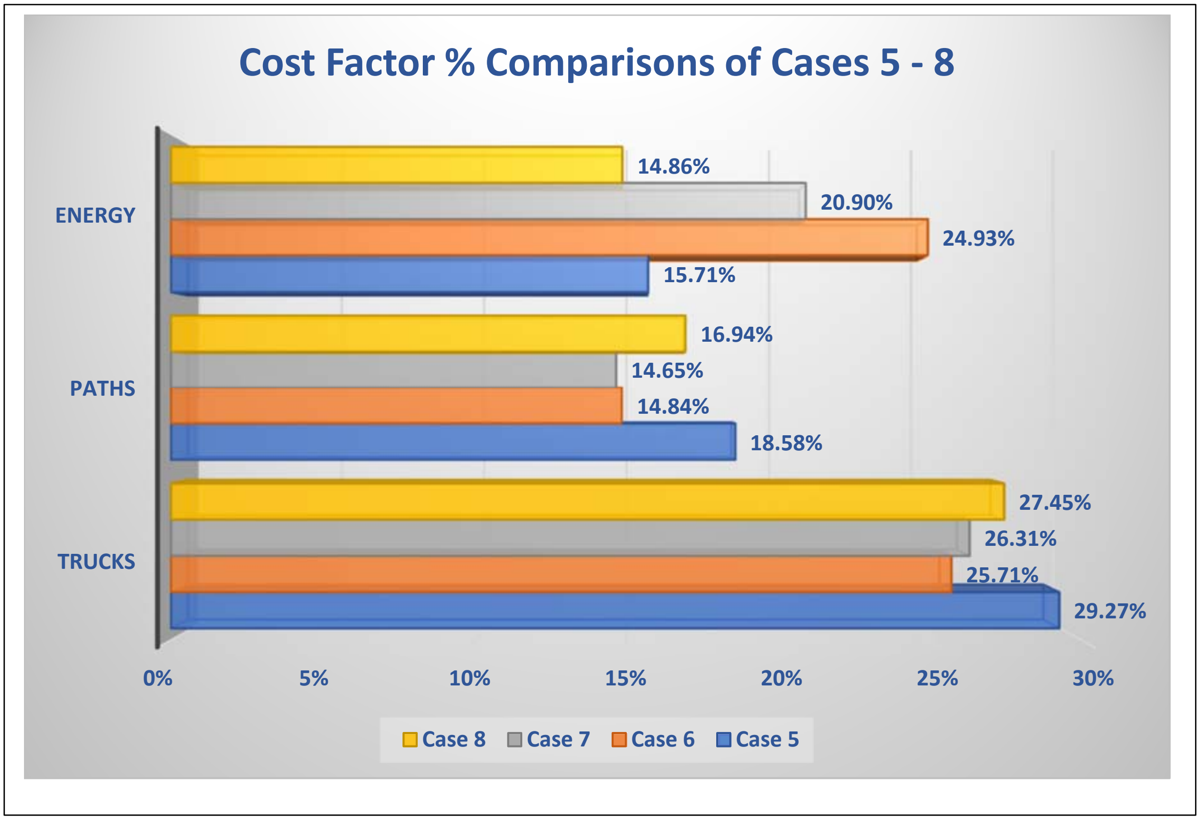

Figure 60: Cost Factor % Comparisons Cases 5 - 8

This is reflected in **Table 102 - Case 5 – Energy and Path Costs Sensitivity Analysis, Combinations Showing Profit**, which illustrates the broader range of positive impact on NPV and IRR for the kW and path percentage factor values analyzed.

Consistent with the **Case Scenario Financial Overview** in **Appendix E**, Cases **1, 3 and 4** appear to have the highest NPV and IRR values of the eight cases e.g., less sensitive over a broader range of increased energy and path costs.

At the base rate of 100% of the nominal energy and path rate, Case 2 does cover its costs and earns money, as reflected in the low positive NPV and IRR values, similar to Case 5, with even lower NPV and IRR values. Cases 1, 3 and 4 have much higher positive values for NPV and IRR, but Cases 6, 7 and 8 do not have positive NPV values.

In conclusion, network authorities have limited upward latitude for increasing costs beyond the previous nominal rates, established prior to the pandemic and risk rail mode sector demand destruction with increased costs.

6.9 Externalities and Subsidies

The rail mode's externalities, with respect to CO_2 emissions do exist, but are a fraction of what transport by road generates. **Figure 61**, below, shows the average impacts of CO_2 of three modes, rail, road and IWW, quantified in terms of € per t/km and € per v/km.

Category	€-cent vkm Rail	€-cent vkm HGV	€-cent vkm IWW	€-cent tkm Rail	€-cent tkm HGV	€-cent tkm IWW
Air pollution	2.14	9.38	1.869	0.004	0.76	1.29
Climate change *	0.124	6.48	N/A	0.25	0.53	N/A
Total External Costs	**2.264**	**15.86**	**1.869**	**0.254**	**1.29**	**1.29**
Difference in Favor of Rail (Rail vs. Truck)	**13.596**		**N/A**	**1.036**		**N/A**

* For diesel freight trains. No electric freight trains listed.

Figure 61: Avg External Modal Cost Impact of CO2

Source: European Commission, ***"Handbook on the external costs of transport***", Version 2019 - 1.1

According to the Treaty of Rome, Article 87(1), State aid is prohibited. There are mechanisms that can help facilitate the shift from road to rail, through the use of subsidies. The basic idea is to calculate the combined impacts of modes competing with rail and subtracting rail's CO_2 impact from the primary competition, which is road. What remains is the calculated rebalance of environmental externalities, with respect to CO_2. According to Article 3. b. Regulation No. 1107/70, an exemption from the prohibition from State aid exists in application to help companies (rail), that in comparison to modes that are not assessed their full external costs, including for infrastructure, then the State (or State designee), is authorized to pay the difference to the company applying for the funds. This provision technically allows public entities and jurisdictions to pay 100% of the difference between modal external costs, although in practice, the amount may be somewhat less and subject to other applications and/or priorities.[77] (Alternatively, all modes could be taxed on equal principles, which would reduce the tax impact on rail. See section 7.6.1 No. 2).

[77] Source: Dablanc, Laeticia,"***Quel fret ferroviarire local - Réalités françaises, éclairages allemands***", Pages 199, 200, 208 and 209.

Chapter 7 – Conclusions

7. Conclusions

7.1 Summary

To summarize the dissertation, the research question is:

"Under selected conditions, can the smaller scale, more entrepreneurial versions of the North American-style of traditional railway enterprise, known as the "short-line" or "regional railway develop a profitable business model in the newly liberalized commercial market and regulatory environment in the EU, as well as in other geographies, with or without integrating complementary business elements ("bolt-on"), as either separate or related enterprises?"

Given those parameters, are there operational business models that stand on their own financially, without the augmentation from other subsectors of complementary activities integrated into the enterprise? If so, what representative operational scenarios would qualify as a stand-alone RU enterprise?

To answer those questions requires an operational simulation costing model to define the costs, with high granularity, as well as potential revenues with the aim of profitability.

What differentiates this PhD can be found in two parts:

1. That disaggregated data with the appropriate geographical scope was generated by the author, using the latest Eurostat data *from the years when the correct levels of disaggregation were still collected*. This has resulted in gaining perspective of the commodity types, general flow densities and origin-destination pairs that were worthwhile candidate cases for more detailed examination.

2. That a platform for analysis was developed to analyze, not only this data, but any other data available between other origin-destination pairs. The structure and formulas are in place for a rapid approximate indication of the prospective profitability, breakeven points of loading units and revenue, identification of each of the cost elements in rank order, as well as sensitivity analyses, as to which input parameters have the highest effect on profitability. With this comprehensive tool, a researcher can quickly determine the general economic feasibility of establishing rail freight service between two points, given the type of service that RU operators have found to be profitable within the European geography.

It became clear that to answer the research question, it would be necessary to establish a framework for analyzing a prospective enterprise, by establishing relevant metrics and a financial and analytical structure that was flexible enough to input different variables and derive a financial result to evaluate.

The result is a tool developed for this Ph.D. that served as a cost simulation model and allowed analysis of a broad spectrum and combination of researcher-defined variables, that generated data for analysis and analyzed the data generated to quantify any reasonable new operational, regulatory or infrastructure-imposed scenarios.

7.2 Conditions for Profitability

As part of the O/D pair selection process, there must be at least one large traffic generator, in the form of a seaport, a large consumption area, a large production area and any multiple combination of those factors.

The nature of the traffic is crucially important, especially in the context of trip cycle costs. Cargo types traditionally hauled by rail, such as ores, grain, steel, chemicals, lumber, stone, cement, forest products, etc., are high volume tonnage, but are usually of a one-way nature, meaning that the trip cycle is paid one way, but the return trip is unpaid.

The return cycle costs must then be included in the cost basis. However, intermodal traffic involving unitized loading units, such as containers, has a higher probability of a paid return trip. Truck trailers also have a high probability of a return trip, as they are often dispatched by not only the trucking companies themselves, but freight forwarders, 3PL logistics providers and direct shippers, as well as integrated companies. Though the same trailers may not themselves make the return trip cycle, the wagons hauling them will return. With the wagons and capacity available at the destination (now an origin), any trailer from any source would have the option of using rail, if the costs were competitive with the customer’s own costs for transporting that same trailer by road, assuming the quality of services were acceptable.

Profit can be greatly enhanced by segments of the trip cycle paid for in both directions, without which, attaining volume and scale would be a multi-year struggle and would often be the difference between profit and loss.

Therefore, a prerequisite for the type of traffic targeted are truck trailers (or containers), hauled in pocket wagons. Another prerequisite is that the truck trailers are “cranable”, that is, structurally capable of being hoisted by a lifting device onto the rail car. An encouraging development is the increasing number of cranable trailers that are entering the service pool, as well as new technologies being developed for terminals that will load to and from wagons horizontally.

The total addressable market potential for commodities hauled in truck trailers or containers is magnitudes greater than virtually any other in the spectrum of commodities hauled by rail.

Addressing the cost side, for the all-rail scenario cases, among the largest single cost categories are equipment leases for locomotives and wagons. (In the case of the four rail-truck case scenarios, the highest costs would be trucking). The easiest and surest way to reduce costs in that category is to simply use older equipment[78] that is equally functional, but having a lower capital cost and therefore a lower lease cost, if not outright acquired by an actual purchase.

While the operating costs of older locomotives may be higher, especially for diesel electric (or hydraulic) locomotives, the reduced capital cost often outweighs the increased operating costs, making that option more viable.

The same is somewhat, but less true for pocket wagons, as an operator would be in a better position to use the newer T-3000 series pocket wagons that accommodate standard trailers, 20 and 40 ft. containers, swap bodies and most importantly, the higher capacity "45" trailers, now increasingly in widespread use.

The older T-2000 pocket wagons can handle 20 and 40 ft. containers, as well as standard truck trailers, but the possibility of losing traffic volume due to not being able to handle the 45 high-capacity trailers and swap bodies is a distinct disadvantage, likely outweighing the reduced lease cost of the lesser capacity T-2000 wagons., as described in the footnote below. [79]

The number of wagons per train is another, though according to some analyses, the least important factor. Care must be taken to select paths that offer longer train lengths, especially in countries that have train restrictions, such as Poland. In general, Poland has a system-wide restriction of 600 meters, however, some paths allow train lengths of 630 meters, which, in the case of the traffic contemplated, means one more pocket wagon loaded with up to two more loading units.

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[78] Examples of equipment brokers can be found at www.rail-assets.com, **www.tealinc.com**, **www.ozarkmountainrailcar.com** and **www.sterlingrail.com**

[79] The primary advantage of the T-2000 pocket wagon, other than reduced cost, is being able to use those wagons in Denmark, which has banned T-3000 pocket wagons, due to an accident in 2021, with fatalities, in which a trailer broke loose from its mountings and collided with a passenger train passing in the opposite direction. Since Denmark is not in the O/D pairs analyzed, it is not relevant to this research, but is nevertheless noted.

In the case of Belgium and the Netherlands, both countries have path restrictions limiting train lengths to as short as 590 meters and other paths allow 690 meters. Each operational scenario must be analyzed to compare the longer train length paths allowed, along with other path restrictions, such as non-electrification, longer and/or circuitous paths and restricted access through line capacity.

For the analyses in this dissertation, operating scenarios of two trainsets per week, each with a round trip with four origin and destination pairs (each named "case *n*"), consisting of 17 wagons, with an 80% load factor and a transport rate of €.90 per kilometer per loading unit formed the base scenarios to apply metrics.

In addition, each of these four O/D pairs had two sub-options of all-rail operations over all route segments or a combination of rail and road segments (at the beginning and ending segments within Poland), bringing the total prospective operational scenarios to eight cases. Given the parameters listed above, these form the basis for the train consist (composition), along with the geographies for operation and markets served.

7.3 Determinations

7.3.1 Service Business Models

The service business models, as described by ***Options 1, 4 and 5 in Chapter 4*** are optimal business relationships objectives. In the context of the research question, however, the portion of "*… with or without integrating complementary business elements ("bolt-on"), as either separate or related enterprises",* is relevant here.

The business service models:

Model 1: RU (operator) and 3PL are integrated and share business responsibilities

Model 4: 3PL (logistics company) making agreements with customers and subcontracting with an RU / traction provider

Model 5: RU (operator) and all customers (shippers) make direct agreements and/or originate/terminate traffic to/from connecting RU(s).

7.3.2 Case Scenarios

Each case scenario was evaluated and according to the metrics of net present value (NPV) and internal rate of return (IRR), the best-case scenario was ***Case 3 – Rotterdam – Posnan, rail only***. The ***second-best scenario was Case 1– Rotterdam – Posnan, rail only*** and the ***third-best case scenario was Case 4 – Antwerp – Posnan, rail only***. ***Case 2*** - ***Antwerp - Wroclaw, Rail Only***, rail had a positive return (fourth best).

Of **Cases 5 – 8**, which included the truck segment from Forst Germany to either Posnan or Wroclaw and return, the best performing of the four which had a slight profit, was **Case 5 – Rotterdam – Forst – Wroclaw**, which ranked at fifth best of all eight cases.

The worst financial performance of all cases was Case 6 – Antwerp (Forst) – Wroclaw, rail and truck, the second worst was Case 7 – Antwerp – (Forst) - Posnan, rail and truck and the third worst was Case 8 – Rotterdam – (Forst) – Posnan, rail and truck. Cases 5, 6, 7 and 8, lost money (did not recover initial capital invested) and had low (or negative) internal rates of return (IRR) and therefore, were disqualified as investment candidates.

Table 112 shows the financial rankings of each case.

Scenarios	NPV	IRR	Ranking	Routing
Case 1	€ 732,416.13	31.39%	2	Rotterdam - Wroclaw, Rail Only
Case 2	€ 91,703.98	19.65%	4	Antwerp - Wroclaw, Rail Only
Case 3	€ 1,189,512.69	40.27%	1	Rotterdam – Posnan, Rail Only
Case 4	€ 428,394.04	25.58%	3	Antwerp - Posnan, Rail Only
Case 5	€ 40,914.51	18.65%	5	Rotterdam – Forst – Wroclaw, Rail and Truck
Case 6	(€ 811,726.63)	6.57%	8	Antwerp - Forst - Wroclaw, Rail and Truck
Case 7	(€ 596,587.25)	9.35%	7	Antwerp - Forst - Posnan, Rail and Truck
Case 8	(€ 469,833.67)	10.68%	6	Rotterdam - Forst - Posnan, Rail and Truck

Table 112: Case Scenario Financial Rank

7.3.3 General Scenario Conditions

While identifying the optimal complementary business service model was part of the whole picture, the direction of the research was also to arrive at findings to determine whether the RU could feasibly operate as a stand-alone traction enterprise, without the augmentation of external or integrated enterprises. To arrive at those findings, different propositional scenarios were modeled, based on the criteria listed above, as to their financial viability.

The findings distilled down to the following scenarios and under the following conditions.

- Older locomotives, either diesel-electric or electric
- Older locomotives that are homologated in multiple countries
- Negotiate a deal with the leasing companies on three different lease scenarios that equipment could migrate to, given market conditions
- T-3000 wagons
- Start with two round trips per week, building frequencies, as market demand requires

- If able, obtain operator status in all countries within which the RU will provide service
- Have multi-lingual operating crews
- Otherwise, enter into JV agreements with other operators over and within the territories to be served, also considering expansion into other markets.

These combinations of conditions offer the best cases for establishing and building a successful RU enterprise.

Under the base case scenario of 17 wagons, with an 80% load factor, a transport rate of €.90 per kilometer and operating two round trip trainsets per week, evaluated with a discount rate of 18.03%, Cases 1, 3, 4 and 5 are indeed profitable, some more than others, as discussed earlier. Specific load factor and variable combinations under which profitability is optimized are identified in the sensitivity analysis in **Chapter 6 – Financial and Risk Analysis** and in **Appendix E – Case Scenario Financial Performance Overview**.

7.3.4 Limitations of Research

To reiterate from the introduction, the limitations of the research are the inability to quantify the following factors:

1) Intangible factors

2) Administrative structural risk

3) Exogenous events, such as the recent pandemic, financial downturns, wars and other unanticipated perils.

In addition, there will not be quantification of other intangible factors influencing financial performance, such as charges for externalities, as there are limited established values or reliable marketplace mechanisms to assess those charges. The objective of this dissertation is to provide an analysis *platform* into which realistic direct revenue and costing data is entered into a simulation model to yield an answer, as to the financial viability of a freight intermodal rail service to selected O/D pairs.

7.4 Where is the Devil?

Though some of the case scenarios seem financially enticing, nevertheless, from the results of research conducted in this dissertation, this author counsels caution in the EU rail sector. The counsel takes the form of the perennial question *"Where is the Devil"* and appears from multiple sources:

1) Government layers that ostensibly promote rail, but have no real policy making power, nor do they cooperate effectively with other public bodies to establish meaningful policies useful to the rail sector. The result is a paralysis of policy, that, in the end, accomplishes nothing.

2) Multiple taxation layers that apply to rail, but inexplicably do not apply to road and maritime modes. In principle, governments should be promoting and finding ways to facilitate modal shift to rail, but instead, impose taxation and regulatory hurdles that diminish the competitiveness of rail.

3) Energy prices continue to rise and diminish the competitiveness of rail. Charging VAT on increasing energy costs is a good example.

4) Infrastructure that is inadequate for operating longer trains, eliminating the advantage of being able to operate trains with enough wagons beyond breakeven, recovering costs and allowing profits to accumulate for reinvestment. A good example is the rail terminal in Duisburg Germany, which is often not able to accommodate long trains, accepting only shorter trains, which then operate at a loss.

5) The inaccessibility of non-mainline rail infrastructure assets to RUs (other than incumbent RUs), to facilitate wagon shunting for train assembly and staging of long trains for ready deployment over the network infrastructure cripples the use of rail, by making non-incumbent RUs dependent on the former incumbents to perform these operations. Not having control over designated yard tracks for these operations cripples the independent RU from the flexibility of forming the right-sized trains for the market route segment, deployment of equipment, crews and establishing higher service standards for customers. In effect, the non-incumbent RUs are held captive to the operational and market priorities of the former incumbent RU, diminishing any market advantages developed by the independent RUs.

To this point, all public terminals operated by the former incumbent RUs should be considered open access, with a neutral, third-party infrastructure terminal manager (or the national IM), controlling the use of critical assets, such as terminals.

For the RU, these additional regulatory and taxation hurdles increase risk and make investment in rail unattractive, as well as disadvantage rail from the viewpoint of the shipper. These practices add unnecessary layers of complexity and make investment in rail a difficult choice.

7.5 Failure Factors

To complete a balanced perspective of operating in either an open or closed access regulatory environment, the following are observations of both systems.

7.5.1 North America Closed Access

Failure factors in North America relate to not being able to maintain the infrastructure to serve customers reliably and expeditiously. Without frequent and reliable service, customers will simply shift to trucks. Pricing power is also crucial. The Class I's have the pricing power and if the shortline cannot convince their Class I's connections of the need to relent on higher rates, rail will not be competitive and will lose to traffic to truck.

Rail often operates at a disadvantage by generally inferior service to truck and with uncompetitive rates, the prospects for rail are often poor. Class I railroads also can unfairly compete with the shortlines by diverting traffic by truck to a reload site located on the Class I's line, circumventing the shortline.

North American railroads also become uncompetitive and drive customers away by imposing numerous extra fees, known as "accessorial charges". These take various forms, the most egregious of which are through "demurrage charges", which assess a penalty fee for either unloading a railcar too slowly and then releasing it or taking too long to load a railcar for the outbound trip. Quite often, it's not the fault of the customer, but of the railroad. In the railroad's zeal to reduce operational costs and offer minimal service frequencies, multiple railcars are placed on the siding for loading and/or unloading. But, if the railroad failed to remove railcars that were already released by the customer, an operational standstill results and for which the customer is charged for the delay. Said in different words, the customer is often penalized for the railroads' self-induced congestion conditions. This has become such an issue, that the regulatory agency in the US, the Surface Transportation Board (STB), held two days of hearings conducted in Washington DC on April 26 and 27, 2022 to learn directly from both customers and the railroads about this and other matters.

Related to the above through service quality (frequency), issues, the Class I railroads have promulgated their version of an operating practice known as "Precision Scheduled Railroading (PSR)", with personnel layoffs and hiring freezes. Ostensibly, this was exacerbated due to the recent "Covid crisis", but the actual beginning of the layoffs was initiated long before the pandemic of 2020. This has resulted in operating employee shortages, because many of those employees furloughed have not returned to the railroads, having found employment elsewhere.

Efforts to either rehire or hire new employees have had limited success, for various reasons. Some of the most frequent reasons are the low tolerance of today's employees to endure the inflexible work schedules that railroad impose on their personnel, disqualification through very thorough drug testing, new hires not satisfactorily completing training programs and many simply quit after finding better, more flexible and often more lucrative opportunities.

In addition, many of those employees who do stay remain highly dissatisfied with the railroads' scheduling practices, with limited time off for medical, family, school and other priorities that emerge in life. This particular issue has become such an acute point that a nationwide rail strike was possible in December 2022, but which did not occur, due to a forced settlement imposed by the US Presidential Emergency Board (PEB), which makes the final ruling, in the case of an impasse in negotiations. However, the ruling was imposed without resolution of one of the main grievance points driving the strike, which was the inflexible work-life balance issues in scheduling. The risk is that the US railroads may lose more operating employees.

The end result distills down to not having enough operating personnel to conduct operations that are consistent, timely and with a management that is easy to work with. The diminishing quality of service, coupled with the additional expenses to the customer through higher tariffs and random accessorial charges, along with unreliable and inconsistent service that customers cannot plan their production processes around mean that not only do the Class I railroads lose market share, the shortline railroads suffer, because they cannot persuade customers to either try or remain with rail, regardless of how good the shortline's service levels and attention to their customers is.

7.5.2 EU Open Access EU

For the EU, the failure points are many.[80] Starting from regulations, the odds are against non-incumbent (or related to former incumbents from another EU country), RUs from the beginning of involvement.

Germany and France are good examples of entrenched administrations that are philosophically and competitively against independent RUs to protect the former incumbent railways' interests. Independent RUs suspect it is unlikely that the policies promulgated by the governments are random events, rather, they are deliberate methods to handicap and diminish

[80] This partial listing of risk factors that independent RUs in the EU are exposed to are compiled from the input paper: European Rail Freight Association (ERFA), ***"Private investments into rail – what framework conditions?",*** (2014), pp 1 - 5

private RUs, all concealed within the cloak of "policy" and "shifting financial responsibility" to synthetic entities, that really do nothing to promote the shift from road to rail and appear to exist solely to hobble the competitive advantages private RUs may offer.

The new entrant and existing non-incumbent RUs are skeptical of the necessity of long and unnecessary extended administrative procedures. Except for the very well financed RUs, either in partnership with the incumbents, large companies and/or integrated shipping companies (such as maritime), the smaller and independent RU has rather diminished probabilities of success.

Many factors are against the independent, private RU, from lack of capital sources, exorbitant energy charges, the necessity to place a security deposit before operating with DB Netz to assure them of payment (affecting cash flow and possibly requiring a bank line of credit), the preference to DB from DB Netz for desirable network slots, the elongated procedures, difficulties in securing sufficient yard space for trains of commercially viable length, not being able to service terminal areas independently without the incumbent's involvement are but a few of the crippling conditions imposed on the private and independent RU sector.

It is ironic that for the stated policy goals of the EC and national governments of being sustainable, with climate change and all the negative externalities of other modes, that rail is not being promoted and given advantages, but rather, has heavy regulatory burdens, taxation and infrastructure handicaps layered on top of their already difficult mission of winning traffic. These negatives all weigh against any business case to be made by RUs and indeed, even the rail mode. (ERFA, 2014).

Incumbents are not immune to failure factors, either. Concerning personnel, in general, a big problem for incumbents is the ratio of production to productivity, manifested as far too many employees for the production realized. As an unavoidable consequence of reform, demands for increases in productivity will inevitably result in reduced employment, because there will be more work done for the constant number of hours worked. The general tenets are to do more with less, which is the ethos of industrial organizations universally, historically, and in the private sector.

However, this trend is not strictly the domain of the private sector. In the process of reform, incumbents (as well as the private sector), have successfully negotiated with unions on labor force reduction, along with more flexible "work rules", in return for agreed levels of compensation. In the case of France, reform initiatives have historically proven tortuous to negotiate and generally not realized, due to the personnel administration and their philosophies of employee and social relationships. That means layoffs are portrayed as nearly "criminal violations" of the social contract and those viewpoints are conveyed to the highest political levels, rendering reform efforts as ineffective. Even if layoffs were to occur, from the SNCF's perspective, there are only so many personnel resources to apply to revenue generating activities, so for marginally or not yet profitable shortline branches, they have no priority. This, of course, affects local branch line services, which lose traffic in a downward spiral, offsetting initiatives to shift road to rail, for environmental reasons and economic retention, as well as ongoing economic development efforts. While there is likely some local, regional and national desire to expand rail freight service within SNCF (or any of the incumbents, such as DB), the inflexibility of work rules and attendant poor productivity doom reform initiatives, with respect to shortline-type local service development.[81]

Some responses to these issues have manifested themselves as solutions such as the emergence of employment agencies that employ pools of qualified personnel, as well as tapping into the retired former operating personnel of incumbents. There are general discussions of autonomous trains, some of which are already operating in Australia, but in the Europe and North America, these prospects are far off and beyond the horizon of reality and implementation.

Labor talent can be difficult for non-incumbent and/or new RU's. Independent RUs are faced with the problems of the qualified labor pool being absorbed by the former incumbents (having been trained by them, get job assignments and are imbued with the incumbent working culture, with its inefficient operational practices). [82] [83]

The difficult issues confronting RUs in the EU, in general, are foundational and require decisive resolution to ensure private enterprise's continued participation in the rail sector and to ensure that the EU accomplishes its stated policy goals of both completing rail sector liberalization and shifting road to rail.

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[81] Crozet, ***"Development of rail freight in Europe: What regulation can and cannot do"***, CERRE Policy Paper (2014) Pp. 30-31.

[82] Dablanc, Laeticia, ***"Quel Fret Ferroviare Local? Réalités françaises, éclairages allemands"***, (2008) P.43, No.5

[83] "*About the staff, new entrants may struggle to recruit driving and service agents, because the professionals already trained existed only at the SNCF. Private operators are unwilling and unable to offer a regime similar to railway status, losing relative attractiveness. Some have found an answer to the problem by setting up their training centres, but this is still too recent to ensure that they have sufficient staff, given the necessary training time (about nine months), and the rapid development of some of these companies. A collective agreement for railway undertakings has been under negotiation since January 2008; it concerns new entrants and SNCF staff not subject to railway status*." Dablanc, Laeticia, "***Quel Fret Ferroviare Local? Réalités françaises, éclairages allemands***", (2008) P.41

7.6 Concluding Thoughts

The research conducted in writing this dissertation has resulted in observations, as to how the railway sector in the EU can be enhanced to fulfill a meaningful and effective role in moving traffic from road to rail and refined to profitability for those who risk participation. The following summarizes those observations.

7.6.1 Recommendations for Policy

Many of the policy recommendations are encompassed in ***Section 7.4 – Where is the Devil?*** It seems incongruous that for the stated broad EU policy goals of shifting road traffic to rail, that so many obstacles exist in the path of those who are trying to facilitate those goals. The following is a summary of policy recommendations.

1. Do not establish unnecessary government layers that nominally promote rail, but have no influence or enforcement powers on policy favoring rail. The management of these lateral layers is difficult, since it appears there is no hierarchical organizational position or political mandate to enforce policies meaningful to the rail sector to facilitating shift road to rail ***and*** do so evenhandedly, without bias favoring the former incumbents.

2. If there are serious intentions of shifting road to rail, then eliminate the multiple taxation layers that are imposed on rail operators that help disfavor rail. In addition, to encourage shippers to use rail, a tax incentive offered to shippers would encourage the use of rail or a tax for all modes along equal principles, whereby the most sustainable ones will emerge by themselves.

3. Energy costs fluctuate, but in general, continue to rise and diminish the competitiveness of rail. Eliminate charging VAT on energy, which are otherwise, ever-increasing, with the rise in energy costs.

4. Eliminate the infrastructure managers' (IM) markup on energy distribution for electricity. Operators should be free to choose the energy distributor of their choice, without being channeled into using the IM as a provider and if the operators choose their own distributor, the discounted energy charge must be passed on to the operator, with no more than a small, regulated markup, to avoid price discrimination. The marked-up energy prices are a big profit center for the IM.

5. Eliminate the necessity for smaller RUs to make a security deposit to the IMs for slots, increasing RU costs and impairing credit for other uses. Not being able to make the

deposit from already scarce funds risks restrictions or even cancellation of RU slot reservations, destroying customer confidence in the RU trying to maintain or secure new business.

6. It is well-known to RUs that terminal Infrastructure is often inadequate for operating longer trains, forcing them to operate shorter trains, so as not to give up their network slots with penalties and loss of priority, which then results in the RU operating at a loss. Since, in the end, the government owns the yard and terminal infrastructure, (as the IM), RUs should be compensated from the IM's, due to the RU being forced to forgo revenue and profit opportunities to fit into the IM's lack of infrastructure capacity. This can be done by credits to the RUs against future IM charges, refunds or even punitive compensation schemes, such as currently imposed on the airlines for delays and cancellations. Fundamentally, it is the same experience of disutility, whether by an RU or airline passenger. [84]

7. Related to the other infrastructure manager (IM) woes that RUs must endure with the necessity to reroute from their reservation of a selected path, due to network maintenance or closure. Not only does traversing the detour path often result in higher direct internal operating cost, the IM, in the case of Poland, charges for the extra kilometers and energy required to use the IM-imposed newly assigned path to detour around the affected area. This is viewed by RUs as bad will and disadvantages them by raising their operating cost through no fault of their own. IMs should adjust this policy, as a matter of fairness. [85]

8. Industry sidings, yard trackage, run-around tracks and use of long track leads (extended track) for train consist assembling should be made available on an open access basis to non-incumbent RUs. For the incumbent RUs to have inherited these assets for their sole use is anticompetitive and disadvantages other non-incumbent RUs. If the independent RUs have, through their expertise, efforts and business acumen, made the effort and succeeded in persuading customers to use rail in such a volume, they should be

[84] Research on such a similar scheme implemented by the Italian Government was conducted Marzana, Vittorio et al., ***"Incentives to freight rail undertakings compensating for infrastructure gaps: Methodology and practical application to Italy"***, Transportation Research Part A (2017), however there was no specific discussion of the basis or the details of the scheme methodology.

[85] Related to the author, verbatim, by E. A. Burkhardt, President of Railworld, LLC and Chairman of Rail Polska, Z.o.o in Poland.

supported with the use of infrastructure that can facilitate building trains to capitalize upon and service that traffic.

9. For those RUs who would like to arrange for their own infrastructure, credit enhancements for financing track extensions, sidings into industries, run-around track, small yards, satellite terminals to accept trains, either for terminal operations or holding for entry into larger yards would be operationally helpful and enhance the transport product offered to existing and prospective customers. While some of these programs exist on a small scale, they are obscure, are complex to implement and have limited funds.

10. Subsidies or shared costs for private RUs who want to establish terminals is not legal and are "anticompetitive", according to EU law. Workarounds, such as covered in Section 6.9 are necessary to support new initiatives for establishing or continuing "shortline" style RU operations in Europe.

11. The cost burden of interoperability through installing onboard signaling equipment (ERTMS) for locomotives is unbalanced, as the former incumbent and public RUs have this cost paid for by the government. To impose the same costs, unreimbursed on the private RUs, is not fair or balanced and is ultimately uncompetitive. The reply from the EC will undoubtably be that it is anticompetitive and against EU policy and law. The answer, in this case, is to amend the policy and law, or at least make specific exceptions, given the heavy capital expense of ERTMS hardware and software.

12. The incumbent RUs have inherited railcars and locomotives from the former State railways. The government should establish a pool of qualified rolling stock available to all non-incumbent RUs, so they can remain competitive. This equipment pool would be maintained by the government(s) or the EC.

13. Alternatively, the government could sponsor a pool of rolling stock provided by private equipment leasing operators, with the initial capital costs covered by the government, but managed and maintained by the private leasing operators. The reduced capital cost would be reflected in the lease rates. Lease operators would be paid a guaranteed higher margin for management and maintenance to compensate for lost revenue on their own leased equipment portfolio that they may experience. This would help equalize the unbalanced competition from the former incumbent RUs, by making rolling

stock available from a greater number of sources, helping reduce costs through further scale, as well as increase the pool numbers of scarce rolling stock. The purpose of this policy initiative is to both fulfill EC competition goals, as well as help facilitate the policy goal of shifting road to rail.

14. If an RU would choose not to participate in a government-sponsored lease pool (or more likely that it would not have been established), the government should offer credit enhancements to these RUs so that they could qualify for credit on leasing equipment.

15. Qualified operating personnel are difficult to find for the non-incumbent RUs and personnel need to be trained with approved programs, generally only available from the former incumbent RU. The government should institute and/or sponsor training regimens to establish a base of qualified and trained operating personnel, available to all RUs.

16. Alternatively, to point 15, private enterprises should be established to train, technically support and function as a labor pool provider for railway operating personnel. In the US, there is a long, successful history of private enterprise and/or RUs cooperating directly with local trade schools and technical colleges for training and job creation, supported with ample State and Federal funding. The underlying motivations are fuller employment opportunities and solving operating staff shortages.

17. There should be established an ombudsmen agency that handles all infrastructure, equipment and maintenance matters on a technical level, to cut through any bureaucratic obstacles RUs may experience for quick resolution of any issues.

18. Expanding the scope of discussion, with particular focus on points 9 and 10, issues regarding future European competitiveness are now in the forefront of priority, with numerous calls from a wide spectrum of business sectors to revise EC industrial policies. In the context of recent US "green subsidies" and overall, general Chinese government subsidies to their industries, European industrial sectors are under increasing pressure to be more competitive. The US ***"Inflation Reduction Act (IRA)"***, passed by Congress and signed into law in August 2022 has been funded with $430 billion. The IRA Act offers not only tax credits (*not* deductions) for investment in manufacturing facilities in the US, but also directs State aid for building factories from both the Federal Government and individual states. Given the vastly lower energy prices in the US vs. Europe alone makes

a compelling economic case for industry. Topics related to those policies are covered in Sections 2.9, 6.9 and 7.5.2. have a direct link to the points made in this connection.

The above recommendations are an overview of the top issues observed during the course of research in this dissertation, the implementation of which could help advance the rail sector.

7.6.2 Recommendations for Industry

It is likely that the larger RUs that are integrated enterprises and/or producers that have considerable political sophistication and know-how to move within and around government. But, the smaller, more entrepreneurial RUs often do not have the scale, financial depth or political relationships of the larger independent or former incumbent RUs. Parenthetically, pooling resources together from other RUs to hire lobbyists and other representatives is a strategy already in play, through numerous industry sector organization and direction by the collective membership to backing a political candidate or party that is sympathetic to their interests could be helpful.

But the single, most effective way to gain market, pricing and political gravity is finding ways to grow larger. The historical and time-proven method is to get bigger through JV's, alliances and/or M&A activity. RUs will develop scale, reduce their costs from sales, general and administrative fixed cost categories (SG&A), to rolling stock, spare parts, fuel purchases and other fixed and variable costs, plus then have the political weight accumulated to generate influence in making the correct elected officials aware of the issues and therefore prospectively positively affect policy and legislation.[86]

7.6.3 Scholarly and Academic

Many of the chapters in this dissertation are modular enough to establish separate research initiatives on the variety of subjects covered.

The most obvious is that the current cost simulation model developed for this dissertation could be applied to different O/D pairs and routing options and/or could be refined further, establishing and incorporating new or additional variable combinations. Associated with that, the underlying data that the current cost simulation model used could be updated using purchased disaggregated data from the Amadeus database and/or any other privately available data sources.

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[86] Many of these points can be found in the "***OECD discussion paper***" by **Van de Voorde and Vanelslander (2009)**

With the availability of good data, other model variations could be developed, for example, using the statistical approach vs. the engineering approach taken in this dissertation, depending on the research objective. [87]

Along the continuum of developing this dissertation with the underlying research, this author explored various other approaches, before the final current approach was undertaken. Among them, further research on the many topics covered within could be further expanded upon using innovative techniques, such as the use of GIS applications or artificial intelligence (AI), incorporating econometric techniques, such as Lasso or Ridge regression to predict traffic and profitability.   Further research in externalities could also be explored, as those will not be covered in this dissertation.

Separately, explorations of the intricacies of EC policy and law could develop legal methods to facilitate policy change refinements that could further assist the rail sector and also in the context of accomplishing EC policy objectives, without being captured by antiquated provisions of the law that have little relevance to today's transport, societal needs and current exigencies. For example, the long-term economic benefits of the finance suggestions made in 7.6.1 and their potential effect on RUs could be a subject.

7.7 Last Thoughts

Finally, it is the author's goal that the research and content within this dissertation offer a contribution to the scientific and academic community, not only for developing a methodological analysis structure for evaluating a current or potential railway undertaking (RU), but to also lay the groundwork for further research and for the analysis methodology to lead to software application tools that not only further the use of rail as a mode, but to apply to other modes of transport or even other fields of research endeavor.

For those in policymaking roles, such as government and regulatory authorities, this research can serve as insight into the financial and operational constraints this industry sector operates under, to more effectively develop policies that address and consider the business realities of operating an RU under the current financial and regulatory environment.

This research work has been a long, undulating continuum of effort, replete with line profiles of curvature and gradient, but in the end, the effort is satisfying, in the knowledge that this work will serve as a diligent and thorough analysis platform.

[87] Blauwens et al., "***Transport Economics***", Seventh Edition (2020), Page 323

It is my intention that this research will be used for the purpose of advancing the broad policy goal of shifting road to rail and to find ways to enrich the business environment to make it attractive to all participants in the rail sector.

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APPENDICES

Appendix A: Corridor Operations Feasibility Studies

Study	Elements Considered	Measures Studied	Geographic Scope	Notes
CREAM (2007)	Inventory of operational, administrative and regulatory problems compiled.	Solution sets to problems developed & compiled	EU to Southeast Europe through Balkans & into Greece & Turkey	Blending of traffic through enroute gateways & terminals, consolidating traffic with a focus on intermodal.
DIOMIS (2007)	Buffer time for cutoff time for trucks to terminals, early arrival times, loading units preferentially if used for round trips, on-time rates, consistency & cost effectiveness.	Price, reliability, internal convenience of using a transport service, through departure frequencies, IT tracking, upside traffic capacity margin, cost effectiveness & inexpensive empty container storage & deployment	N/A	Analyzed service elements to consider in detail, so that the prospective intermodal service would be attractive to shippers and freight forwarders
FLAVIA (2007)	Qualitative service elements compiled as necessary for a prospective service acceptable to shipping community including eliminating req. that entire trains or blocks necessary, as w/other rail services. Offered	Operational cost structure with generally universal and common cost elements analyzed	Focus on detailed trade flows by specific goods categories, identifying those most likely to be transported by rail	Network accessibility from other countries considered contributing to financial performance & developing

	service was that frequent departures planned allowed logistics providers, shippers & direct customers w/consistency req. for internal planning & production processes.			scale through connections to terminals and hubs along the corridor.
REORIENT (2007)	Cargo categories, time (performance requirements) & shipment sizes, along with a comparison of the same shipments going either solely by rail, truck or combination of modes, including ferries from Sweden to Poland and reverse.	Simulated realistic operational performance scenarios and their respective costs, given various parameters. Qualitative factors measured by RP survey of shippers conducted by Norwegian Institute of Transport Economics. Quantitative cargo flow research was collected and served as inputs into several models.	Corridor linking Scandinavia (FI, NO, SE), Eastern Europe (PL, CZ, SK, AT), & SE Europe, Balkans (AT, RO, BG, RS, MK), Greece & Turkey.	Assess the probability of shippers selecting rail, given a set of necessary performance and cost parameters.

Table A 1: Summary of Core Elements of Corridor Feasibility Operational Studies

Appendix B: Data Development Process

B.1 Preface

Data structures needed to be developed consistent with the empirical requirements of the research question. Those data structures were the base elements of a demand-oriented database, in which known or observed flows were contained within, as the tables in the database supplies data to later model applications, whatever form they took, as well as to detect patterns in the data.

B.2 Process Scope of Work Overview

There were 52 separate tables generated from the collection of disaggregated data sets from Eurostat that were catalogued. From those data sets, the tables that were relevant to this research were extracted and analyzed, as to how they could be combined to identify the volume and types of data needed for analysis of traffic data between O/D pairs.

The software used for developing the customized queries was Microsoft Access 2007 and later Access 365, being used on a more robust desktop computer to better handle the heavy processing loads experienced.

Data extraction was a multistep process. Consider the volume of data records generated by linking tables of complementary information by common data elements from each table. That entailed joining the data elements of origins, destinations, 52 different product or commodity categories, along with their respective tonnages, kilometers and time between each unique set of O/D pairs.

The accumulation process of paths was duplicated for each cargo consignment in the O/D matrix generated. This meant that each record for every O/D pair had many multiple combinations of this data, resulting in a massive number of records and the first iteration generated over 20 mm records.

Therefore, for each mode, it was necessary to reduce the universe of the matrix of consignment paths using SQL queries for selectively filtering the data and to build a more manageable database. Even with the paring down of the O/D paths through filtering, the matrix for each mode still resulted in approximately 488k records for rail and over 3.7 mm records for trucks.

These steps were needed for each mode, rail and road.

B.3 Data Source

The base data itself was sourced from EuroStat in 2010, which at the time, still had data disaggregated down to useful levels. This data is no longer available, as the collection methods and detail were diminished, due to an EU policy move towards "harmonizing" data collected and partially due to the later enlargement of the EU through newer states.

Unfortunately, data from Eurostat today is not sufficiently disaggregated and will not give the result required to analyze the nature of the traffic between O/D pairs.

The data tables used were from the ETIS_2010 observed, modeled and harmonized data tables.

The more refined and usable data was derived from the research previously developed by the team of consisting of *Karlsruher Institut für Technologie (KIT)* in Karlsruhe, Germany, headed by Professor Kay Mitusch, along with cooperation from two highly respected the private research organizations:

- Panteia BV of Zoetermeer Netherlands
- Decision Support and Management Information Systems (DEMIS) BV of Delft Netherlands

B.4 Base Data Element Requirements

The analysis of the traffic volume between O/D pairs required the following information:

Origins
Destinations
Tonnages per year
Product categories or commodities
Kilometers between O/D pairs
Time between O/D pairs (for road)

B.5 Geographic Level

The data required for accurate analysis is at a good resolution needed to be, at the minimum, at a NUTS2 level data (regional) and more optimally, NUTS3 level, which was equivalent to the county level in the US. (One could go with even more detail with local administrative units (LAU), but the level of detail is unnecessary).

With the data sets available, the origin and destination codes were expressed as a nine-digit number, with the first three numbers corresponding to the country code, which is NUTS1 level, the second set of three numbers would correspond to the NUTS2 level and the third set of three numbers corresponds to a NUTS3 level.

Example:

Field Name	Value
StatLevel	3
ETISCountry	BE
NUTS_ID	BE211
ETISZone1_ID	102
ETISZone2_ID	102020
ETISZone3_ID	102020101
Level 1 Name	Belgium
Level 2 Name	Prov. Antwerpen
Level 3 Name	Arr. Antwerpen

Table B-1: Tables Structure NUTS3 Level

B.6 Product Category and Commodities

The commodities were sourced from the NST2 table, from which up to 100 categories of different product sectors were possible. In this table, drawn from Eurostat, samples were over 52 different product sectors (or categories). Of those, 14 categories were relevant to this research and the table was filtered for those categories that had the highest possibility of being transported in containers or trailers.

The categories:

NST ID	Description
3	Other fresh or frozen fruit and vegetables
12	Beverages
13	Stimulants and spices
14	Perishable foodstuffs
4	Textiles - textile articles and man-made fibers
5	Wood and cork
69	Other manufactured building materials
91	Transport equipment
93	Other machinery apparatus and appliances engines parts thereof
94	Manufactures of material
95	Glass glassware ceramic products
96	Leather textiles and clothing
97	Other manufactured articles
99	Miscellaneous articles

B.7 Process in Detail

The following is the general process developed to generate the tables comprising the database needed for analysis for both road and rail.

Step 1

Collect the tables needed for combining the base information.

Table Name	Description	Level	Notes
Originzone_3	ID, name & description of originating point	NUTS3	
Dest_Zone_3	ID, name & description of destination point	NUTS3	
NST2	Commodity ID, name & description		52 types
F_imp_rail	Origin, Destination, distance origin to destination, time - minutes		Impedance table
F_transport_rail_disaggregated	Origin, Destination, NST2, volume		Annual volume

Table B-2: Data Tables Required for Rail

Table Name	Description	Level	Notes
Originzone_3	ID, name & description of originating point	NUTS3	
Dest_Zone_3	ID, name & description of destination point	NUTS3	
NST2	Commodity ID, Name & description		52 types
F_imp_road	Origin, Destination, km distance, time in minutes		Impedance table
F_transport_road	Origin, Destination, NST2 & tonnage		Annual volume

Table B-3: Data Tables Required for Road

Step 2

It was necessary to filter data to relevant criteria for the research because the number of records in the table was so large. For rail data, the conditions were:

a. Distance between O/D pairs >=500 km <=1650 km
b. Yearly tonnage between O/D pairs >= 10,000 tons

That reduced the number of dataset candidates' records substantially by filtering out data not meaningful to the analysis, such as stray traffic between O/D pairs of 10, 100 or 1000 tons or such minimal values per year. Records with such low values would not be useful in later filtering out the types of commodities targeted, such as those commodities that had the highest probability of being transported in loading units, such as containers. To achieve that, it is necessary to then build a query to filter records to generate table subsets that will later be the basis of more focused queries combining those tables and having a manageable set of records.

Step 3

Generate an SQL query, filtering from the 52 different product sectors (or categories), the 14 categories relevant to this research. Those categories have the highest possibility of being transported in containers or trailers.

The categories:

NST ID	Description
3	Other fresh or frozen fruit and vegetables
12	Beverages
13	Stimulants and spices
14	Perishable foodstuffs
4	Textiles, textile articles and man-made fibers
5	Wood and cork
69	Other manufactured building materials
91	Transport equipment
93	Other machinery apparatus and appliances engines parts thereof
94	Manufactures of material
95	Glass glassware ceramic products
96	Leather textiles and clothing
97	Other manufactured articles
99	Miscellaneous articles

Table B-4: Subset of NST2 Product categories likely transported by container or trailer

Source: Eurostat (2009) and Self-compiled

Step 4

There are now tables that have been generated by the previous queries, based on the above - mentioned queries. Having these tables with filtered data much reduces the size and computation time for data handling.

These filtered tables will now become the underlying tables for further, more detailed queries, based on the qualified (selected) data. Having these tables at hand now allows the researcher to build queries with a flexible set of relationships. Figures A-1 and A-2 are diagrams of the resulting relationships between the tables.

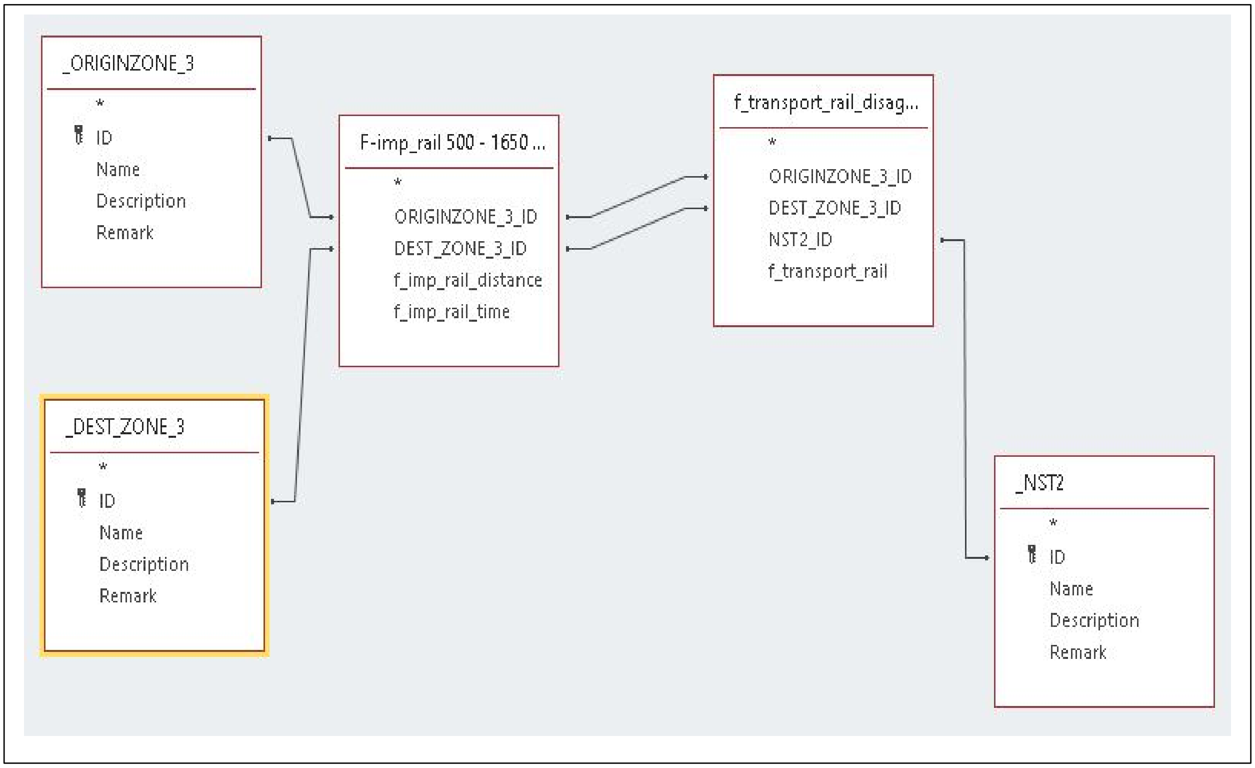


Figure B-1: Data Relationship between Rail Tables

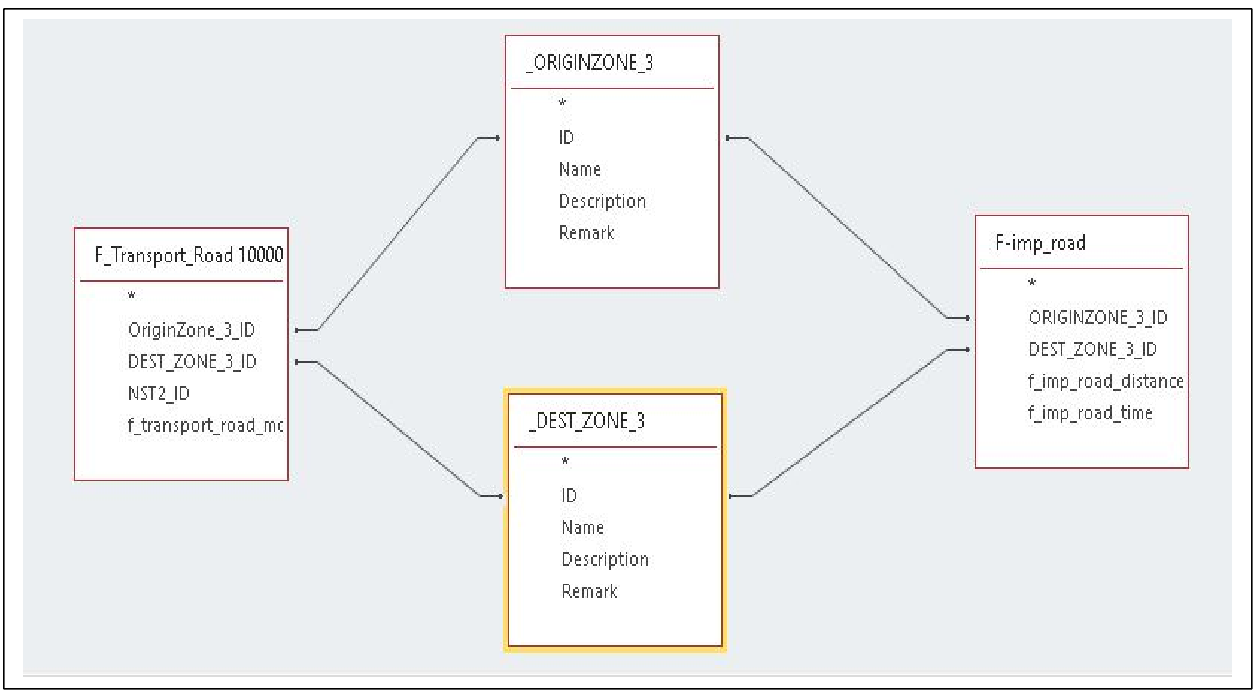


Figure B-2: Data Relationship between Road Tables

Note that in the road version, it was unnecessary to include the NST2 table, unless a specific commodity or category name was required for reporting purposes.

Step 5

Now that the amended tables have been compiled with the filtered data, those will serve as the basis of further queries that can be filtered further by any data element criteria. The data generated from the query can be saved as a table within the Access database (consisting of many tables and queries), exported to a spreadsheet for conditional formatting or further reduced to even smaller tables for specific criteria.

Step 6

With the underlying tables generated, it is now a matter of analyzing the data to determine where the heaviest traffic flow is for the commodities being targeted.

Step 7

Also, there are "impedance" reference tables for both modes, which include both kilometers and time between OD pairs for trucks and kilometers for rail.

Combining data elements from the following three tables would result in a table structure with the data elements extracted by combining data tables as shown below.

Source Tables:

1) Rail or road transport tables
2) Rail or road impedance tables
3) NST2 table

Table with Impedance Values and Extracted Data Elements
Origin Zone
Destination Zone
NST2_ID
NST2_Name
Tonnage
Kilometers
Road Time
TEU
TEU-Week

Table B-5: Subset of NST2 Product categories likely transported by container or trailer

Source: Eurostat and Self-compiled

The last two data elements would be calculated fields in the query that would build the table. There was no estimation of empty trips or empty container loads since the load factors in the model are selectable in reference tables.

The above summarizes the general process of how filtered rail and road data was developed.

B.8 Conversion of Tonnage to Loading Units

As described in Chapter 5, in section 5.2.1, to evaluate traffic volume between O/D pair candidates, it was necessary to develop a tool to convert tonnage values into standard loading units, of the type of cargo that had the highest likelihood of being transported in a standard loading unit, such as a container or truck trailer. This would require a formula to convert tonnage into loading units, of which the standard sizing would determine the wagon types and number of wagons required.

Simplifying to estimate train frequency and equipment required between O/D pairs, one 40 ft. container is equal to approximately one flat wagon or pocket wagon for a trailer, which in turn is approximately equal to one 40 ft. container in total TEU.

To convert freight category tonnage volume data into something useable, one would need to see the relationship between the category of freight shipped and the loading unit used, such as a 20, 30, 40 or 45 ft. container or a truck trailer. This would require a formula to convert tonnage into loading units, of which the standard sizing would determine the wagon types and number of wagons required.

Conversion of Volume to Containers

To convert freight category volume data into something useable, one would need to see the relationship between the category of freight shipped and the shipping unit used, such as a 20, 30, 40 or 45 ft. container. This would require a formula to convert volume into containers.

EcoTransIT is the trade name of a consulting firm in Hannover, Germany, also known as IVE GmbH. The organization has developed a model to estimate the environmental impacts of transport, given a shipment using different modes of transport and/or by carrier. In this case, they are estimating per TEU/km emissions, based on the calculated average net load of a container. EcoTransIT's formula uses the following assumptions:

1) The ratio of 20 and 40 ft. containers is 2:5, translating to 2 TEU:10 TEU or 1.7 TEU average

Container Type	Number	Equivalent TEU	Total TEU
40 ft.	5	2	10
20 ft.	2	1	2
Totals	7	~1.7	12
Formula	**12/7 = 1.7**	**----------------→**	**1.7 Average TEU**

Table B-6: Average TEU

2) The average empty weight per TEU = 1.95 tons
3) The average lading (load weight) per TEU = 10.5 tons
4) Combining 2 + 3 would yield (1.95 + 10.5) = average gross weight of 12.45 tons per TEU

Type of Cargo	Lightweight Cargo	Average Cargo	Heavyweight Cargo
Weight / Category	6 metric tons/TEU	**10.5 metric tons/TEU**	14.5 metric tons/TEU
Avg Empty Weight	1.95/TEU	**1.95/TEU**	1.95/TEU
Totals	**7.95/TEU**	**12.45/TEU**	**16.45/TEU**

Table B-7: Total TEU per Cargo Category

5) Lightweight (volume) loaded container assumptions are that:
   a. Lightweight, but volume cargo is transported in 40 ft. containers
   b. Lightweight cargo will use 90% of the container's volume available
   c. Lightweight cargo will use 50% of the container's weight capacity
   d. The average empty container weight is 1.9 tons (Table A-7)
   e. The net weight of a lightweight loaded container is 6 tons per TEU (Table A-7)
   f. The total weight of the loaded lightweight container is 7.9 tons (Table A-7)

6) Heavy weight cargo is carried in both 20 and 40 ft. containers
   a. Heavyweight cargo is assumed to use 90% of the weight capacity of the container
   b. The net weight of the loaded heavyweight container is 14.5 tons per TEU (Table A-7)
   c. The empty weight of the empty container for heavy category of cargo is 2 tons per TEU (Figure 4)
   d. The total weight of the container used for heavyweight cargo is 16.5 ton per TEU (Figure 4)

7) A 1.7 ratio is applied to the mix of 20 and 40 ft. containers, resulting in 5 x 40 ft. containers and 2 x 20 ft. containers = 12 TEU

Aggregating the total volume in TEU will thus be translated into the number of containers inbound and outbound at a port or for the purposes of determining traffic volume between an origin and destination. However, simple aggregation of TEU derived from a tonnage volume by itself will not accurately determine the equivalent number of containers, as there is also a distribution of different container sizes and categories of weights between the container sizes.

The following is a procedure to develop a conversion formula to apply to the data. To determine tonnages according to a known distribution ratio and the correct number of containers, the first step is to ensure that only the actual cargo weight of all the container categories is counted and not the weight of the containers. The reason for this is that the tonnage values between O/D pairs are expressed as cargo transported only, without container weights.

Given the matrix of container and weight combinations from above and applying the 2:5 distribution, for every 7 containers, there will be a total tonnage of cargo. That value must be summed and divided by the number of TEUs in the 2:5 mix. For example, for every combination of seven containers, there will be a total of 107 tons of cargo distributed over 12 TEU and within 2 (two) 20 ft. containers and 5 (five) 40 ft. containers.

Given: 107 Tons / 12 TEU = 8.916667 tons per TEU

Since the intent of this analysis is to determine the number of 40 ft. containers, (also considering that 2 (two) 20ft. containers = 1 (one) 40 ft. container), it is necessary to calculate average tons per TEU and then apply the distribution formula to calculate the tonnages of each category type and add them together to arrive at the total TEUs for the range of container types and weight categories.

Given: X / 8.916667 = Y

Where:

X = Tons of lading (the cargo loads aggregate between OD pairs)

Light 40 = L40 = 6/12 * Y/2
Heavy 40 = H40 = 4/12 * Y/2
Heavy 20 = H20 = 2/12 * Y

Set up a matrix thus:

Notes	Tonnage	# TEUs	Type # TEUs	Type # Containers	% (Distribution) Type Containers	Label	Weight by Type Container
Enter tonnage volume from data →	Enter OD Pair Ton Volume here	Tons per TEU (8.9167)	6/12*Tons per TEU (8.9167)	Type # TEUs/2	Type # TEUs /∑ Type # TEUs	40 Ft. Light	6 (tons)
4/12 (1/3) of TEUs →			4/12*Tons per TEU (8.9167)	Type # TEUs/2	Type # TEUs /∑ Type # TEUs	40 Ft. Heavy	10.5 (tons)
2/12 (1/6) of TEUs →			2/12*Tons per TEU (8.9167)	Type # TEUs	Type # TEUs /∑ Type # TEUs	20 Ft. Heavy	14.5 (tons)
Totals			∑	∑			

Table B-8: Setup Example of Spreadsheet

Example:

A nominal figure of 20.000 tons between O/D pairs., yields:

20,000 tons / 8.916667 tons per TEU = 2243 TEUs

What is the distribution of TEUs and number of containers? Setting up a spreadsheet, per the above matrix gives the following results.

Tonnage	# TEUs	Type # TEUs	Type # Containers	% Type Containers	Label	Type Weight by Type
20000	2242.99	1121.50	560.75	42.86%	40 Ft. Light	6
		747.66	373.83	28.57%	40 Ft. Heavy	10.5
		373.83	373.83	28.57%	20 Ft. Heavy	14.5
Totals		**2242.99**	**1308.41**			

Table B-9: Sample Scenario

Using this tool will help evaluate selected O/D pairs for estimated container volume potential later in this chapter and to apply to the costing model in subsequent chapters. Simplifying to estimate train frequency and equipment required between OD pairs, one 40 ft. container is equal to approximately one flat wagon or pocket wagon for a trailer, which in turn is approximately equal to one 40 ft. container in total TEU.

Appendix C: Cost Simulation Model

Costing Model Spreadsheet Tool

A tool was developed for the purpose of evaluating selected O/D pairs for estimated container or equivalent trailer volume potential and to apply to the costing model spreadsheet tool.

C.1 Use of the Spreadsheet Model

For a quick start, simply go to row 9 of each of the worksheet tabs of numbered cases (**Cases 1 to 8**) and enter the number of anticipated trains per month. Eight trains per month equates to a realistic 2 trains per week, which is the minimal base case to interest freight forwarders, shippers, trucking firms and steamship lines. Once the changes are put in observe the metrics and changes when different numbers of trains are entered.

The spreadsheet has been designed to be a versatile simulation and projection tool, with more capabilities added to it later, such as integration into standard financial analyses, revenue optimization and also to have different service scenarios added.

There are "place holders", in the form of worksheet tabs that have titles and have been partially developed, but have not yet been refined or tested. A good example of this is the ***"Cases"*** worksheet tab, the intention of which is to be able to analyze multiple segments simultaneously and in combination with each other. The **"Inc. Statement"** worksheet tab was an early iteration of the individual cases that provided the underlying structure for the individual worksheet cases tabs. (For the purposes of this analysis, it is inactive and not integrated). For the purposes of this analysis of the selected origin-destination pair and for purposes of more detail per case, the spreadsheet model will analyze each case individually.

Underlying the formulas of each worksheet case are reference tables that provide the data needed for the base case assumptions. The operative reference table tabs are:

C1.1 Administrative Personnel

This is where the sales, general and administrative (SG&A), personnel are placed. For payroll taxes, benefits, pension, vacation time, holidays, etc., the broad multiplier of .50 is used to estimate personnel costs. This multiplier can be changed to whatever is calculated to be more accurate for whatever country the RU would be based and operating within.

C1.2 Operating Personnel

This tab is not active, with respect to integration into the cases yet, as there are many details that must be worked out first, such as payroll tax rates, individual country working condition scenarios and the like. Instead, the individual cases tabs reference a labor rate table in the assumptions tab, described next.

C1.3 Assumptions

This tab has a number of the underlying assumptions used by the individual ***Cases*** tabs. The assumptions are, as follows:

Inflation Δ Increase (Decrease) – This section allows accommodation for inflation rates of the user's choice by year and rate. Years 2021 and 2022 in each case worksheet tab use this table to calculate increases for both revenue and expenses.

Energy Charges – this table eventually will be used for referencing energy costs, per each country's network statement. For the purposes of calculation of energy costs, these costs are instead carried in the Network Charges worksheet tab, described below.

Account Category – this section will be later used as a basis for calculating cash flow needs and is not being used in the cases worksheet tabs.

Depreciation – this section will be used later to calculate depreciation, but it is not used in the cases, since the equipment will be leased.

Rolling Stock – this section is used as an internal reference for general rolling stock characteristics. Portions of this section are used by the cases worksheet tabs for calculating locomotive and wagon lease costs and insurance, as well as some physical characteristics.

Operational – this section is to be used later for the addition of different commodities and wagons. It is not currently used for the cases worksheet tabs.

Infrastructure / Train Path – This is not currently used. See the ***Network Charges*** tab for the reference tables.

Scenario 1 – This is not currently used and now handled by each individual cases worksheet tab.

Labor Rates – this section is used as the reference table underlying the labor cost calculations in the cases worksheet tabs. The labor rates per hour and social cost (additives), are changeable and flow through to the labor cost formulas in each the cases worksheet tabs.

Operating Personnel Needed – This section uses the reference values of the labor rates section above to calculate labor costs, which are based estimated hours required to travel a route segment. The hours are all changeable.

Train Characteristics for Path Pricing – this is an internal tool used to calculate path costs from either DB Netz or the **CIS (Charging Information System)** tool, offered by **RailNetEurope (RNE)**, the clearing house for rail network paths in Europe.

Working Capital – Not used

C1.4 Revenue Scenarios

This section is the underlying table for revenue in the cases worksheet tabs. I have been experimenting with slide bars for variable load factors and the per kilometer freight rates. These tools need to be refined, but are functional for Cases 1 and 5. Any of the rates, wagons or load factors are changeable and will flow through to the revenue of each of the cases worksheet tabs.

C1.5 Network Charges

This section is the nucleus of path and energy costing for the operational scenarios. It draws data from each individual country's network statements and the **DB Netz's Trassenfinder** network path and energy pricing tool (https://trassenfinder.de), or the **CIS (Charging Information System)** tool, offered by **RailNetEurope (RNE).** The data collected from these resources are:

- Route kilometers
- Path cost
- Kw hours used, either for diesel or electric locomotives
- Transit time
- Estimated power cost

From this data, the following metrics can be calculated:

- Cost per train/kilometer
- Kw average per kilometer
- Kw average cost per kilometer
- The actual energy cost, based on each country's Kw rate, as published in their network statement documents
- Average speed

Also included in this section are estimated truck rates between Forst and either Wroclaw or Posnan.

As regards the path and energy costs applicable to Poland, there were so many locomotive and path combinations that it would have been such a complex undertaking to examine every locomotive, Kw rating consumption combination and path permutation. As a practical solution, the Kw ratings and consumption rates for similar German locomotives were applied to Poland, by averaging.

For example, in the Wroclaw and Posnan metropolitan constellation of communities, they share five and four communities, respectively. Each one of those "sub-communities" within the metropolitan region is a certain distance from two different border crossing points with Germany. In each case, the average of all those distances was calculated and applied to the Kw rate per kilometer to arrive at the energy costs.

Those energy costs, in turn, were indexed to German Kw consumption rates for similar locomotives. In that way, it was possible to arrive at realistic energy costs, which are not available from the **CIS (Charging Information System)** tool, offered by **RailNetEurope (RNE).**

Transit times were calculated by considering realistic average kilometer per hour speeds between points and applying them to the known distances. The transit time figures were then used as a basis to calculate labor costs, as applied to the railway segments in Poland.

C1.6 Poland Rate Factors

This is a table taken from the Polish Railway's network statement for rates per kilometer by train weights to arrive at a "rate factor". Initially, this was used for calculating path costs in Poland, but the use of the **CIS (Charging Information System)** tool, referenced above, made this unnecessary. Electric charges are on a per train kilometer basis. This tab remains available as a resource, but is not used the case calculations.

C1.7 NL Rate Factors

This is a table taken from the NS's network statement for rates per kilometer by train weight categories to arrive at a cost per kilometer. Initially, this was used for calculating path costs in Poland, but the use of the **CIS (Charging Information System)** tool, referenced above, made this unnecessary. Electric charges are based on a per Kw/hr. basis. This tab remains available as a resource but is not used the case calculations.

C.2 Case Scenarios

As discussed in the first part of this section, this worksheet tab originally was intended to be able to analyze multiple segments simultaneously and in combination with each other. For the purposes of the analysis of individual cases, it is inactive and not integrated, but remains to be further developed.

In conclusion, traffic scenarios can be selected, in all numbered case tabs worksheets by going to row 9 of each of the cases and entering the number of anticipated trains per month. No allowance was made for 4.33 weeks in a month or for the shortened month of February. It's simply 2 trains per week X 4 weeks in a month = the number of trains per month. Notice that all Decembers have half the number of trains and the reason for that is to account for the holidays of Christmas and New Year.

Any of the parameters, such as labor rate per hour, inflation rates by revenue, variable or fixed costs can be adjusted in the **Assumptions** tab.

Revenue rates per kilometer and load factors can be amended in the **Revenue Scenarios** tab.

All network charges and energy charges can be amended in the **Network Charges** tab, as new information becomes available.

The number of administrative personnel, their costs and additive multipliers (insurance, pension, vacation, taxes, etc.), can be changed in the **Admin Personnel** worksheet tab.

C2.1 Ratios

This tab was intended to capture metrics from each case for each year. Upon review of this layout, this will likely be revised considerably. While the structure is there and it does display interesting metrics, it is now used mostly as an internal checking tool.

C2.2 Cases 1 – 4 Overview

This tab was originally intended to consolidate Case 1 – 4 data in a condensed, high-level view of the first four cases. While it has turned into somewhat of a "scratch sheet" to test metrics and graphing options, it is nevertheless useful in getting a good overview. The tables are mostly dynamic and change when assumptions change or number of trains are added or subtracted. It is not a finished product, but is a basis for later refinement and the final version of the dissertation.

C2.3 Cases 5 – 8 Overview

This tab consolidates Case 5 – 8 data in a condensed, high-level view. The case matrices in rows 3 – 10 are dynamic and change with different values placed in the underlying reference tables and/or the numbers of trains for each cell in the "G" row of the case worksheet tabs.

C2.4 DB Routes

This tab is the underlying reference table for trains operating in Germany in each of the cases. The source of this is the *Trassenfinder* utility of DB Netz.

In synopsis, this spreadsheet tool is intended to give a higher-level view of the general and relative profitability of prospective origin and destination case scenarios, as identified in the initial data analysis. While the structure is there to expand this tool, the immediate purpose is to be able to analyze the disaggregated data that has been accumulated to apply to this PhD work, in an organized, consistent and structured way.

Appendix D: Formulas

After the profit (or loss) is calculated, the model will help determine the optimum trip combination.

The overview products from the analysis will be:

- Contribution margin (or profit per loading unit)
- Fixed costs
- Variable costs
- Breakeven
- Operating income
- Optimal OD pair(s)

Contribution Margin (Profit per loading unit)

Contribution margin = Revenue – variable cost – fixed costs

Fixed Costs

Fixed cost = Loading units (Trailers) * (Revenue – Variable Costs)

Breakeven for Units or Trailers

$$Breakeven\ in\ Loading\ Units\ (Trailers) = \frac{Fixed\ Costs}{Revenue\ per\ Unit - Variable\ Costs\ per\ Unit}$$

$$\boldsymbol{B_u = \frac{F_c}{R_u - V_c}}$$

Where:

Breakeven quantity of Units (trailers)	B_u
Fixed costs	F_c
Revenue per Unit (trailer)	R_u
Variable costs per Unit (trailer)	V_c

Operating income

Operating income = (selling price – variable costs) * (quantity of loading units transported – fixed costs)

Appendix E: Case Scenario Financial Performance Overview

Without Truck Multiple for Cost and Revenue

Scenario	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
NPV	€ 732,416.13	€ 271,291.48	€ 1,189,512.69	€ 428,394.04	€ 241,329.69	-€ 611,311.45	-€ 424,802.81	-€ 298,049.23
IRR	31.39%	22.67%	40.27%	25.58%	21.87%	9.07%	11.64%	13.19%
Rating	2	4	1	3	5	8	7	6

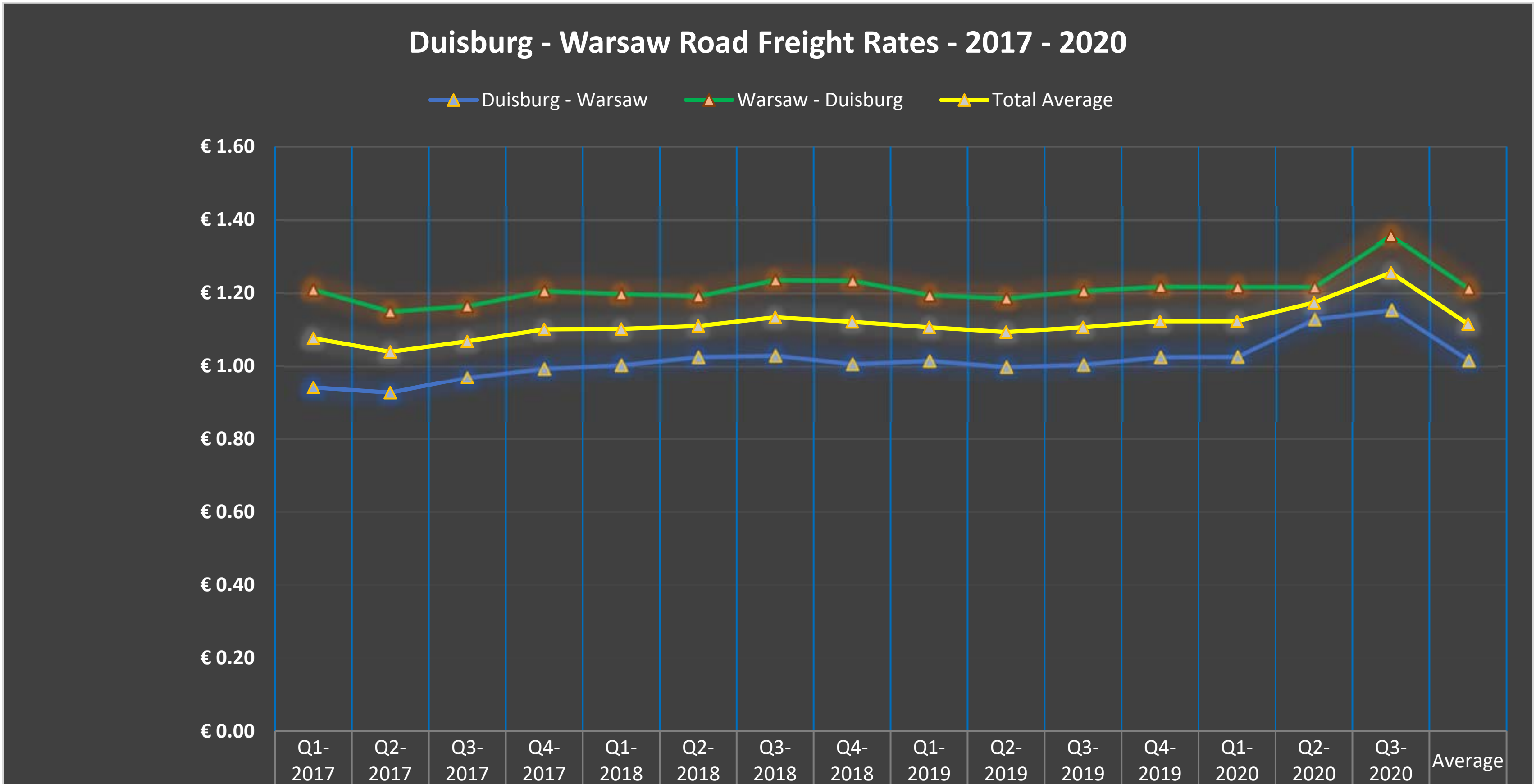
Table E-1: Financial Performance of Cases without Multiple for Truck Revenue

With Truck Multiple for Cost and Revenue of 1.2

Scenario	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
NPV	€ 732,416.13	€ 91,703.98	€ 1,189,512.69	€ 428,394.04	€ 40,914.51	-€ 811,726.63	-€ 596,587.25	-€ 469,833.67
IRR	31.39%	19.65%	40.27%	25.58%	18.65%	6.57%	9.35%	10.68%
Rating	2	4	1	3	5	8	7	6

Table E-2: Financial Performance of Cases with Multiple of 1.2 for Truck Revenue

APPENDIX F: SENSITIVITY ANALYSIS – ROAD FREIGHT RATES



	Q1-2017	Q2-2017	Q3-2017	Q4-2017	Q1-2018	Q2-2018	Q3-2018	Q4-2018	Q1-2019	Q2-2019	Q3-2019	Q4-2019	Q1-2020	Q2-2020	Q3-2020	Average
Duisburg - Warsaw	€ 0.94	€ 0.93	€ 0.97	€ 0.99	€ 1.00	€ 1.03	€ 1.03	€ 1.01	€ 1.02	€ 1.00	€ 1.01	€ 1.03	€ 1.03	€ 1.13	€ 1.15	€ 1.02
Warsaw - Duisburg	€ 1.21	€ 1.15	€ 1.17	€ 1.21	€ 1.20	€ 1.19	€ 1.24	€ 1.23	€ 1.20	€ 1.19	€ 1.21	€ 1.22	€ 1.22	€ 1.22	€ 1.36	€ 1.21
Total Average	€ 1.08	€ 1.04	€ 1.07	€ 1.10	€ 1.10	€ 1.11	€ 1.13	€ 1.12	€ 1.11	€ 1.09	€ 1.11	€ 1.12	€ 1.12	€ 1.17	€ 1.26	€ 1.11

Figure F-1: Sensitivity Analysis – Road Freight Rates **Source:** Ti-Upply Q1-2020 (2020)

Appendix G: Tables of Cost Categories

G.1 Fixed Costs

Advertising & Marketing
Personnel
Payroll Taxes (FUTA, SUI, etc.)
Commissions
Bank Fees
Professional Fees (legal and accounting)
Professional Fees (Safety and Operating Certificate)
Rent
Office Supplies
Postal charges
Utilities
Insurance (Liability, cargo, railway liability)
Phones (Mobile and Office)
Travel
Dues & Subscriptions (Chambers of Commerce, Professional)
Software Expenses
IT Consultant
Tax Accountant
Meals & Entertainment
Sales Expenses
Automotive
Depreciation
Organizational Costs (registrar, notary, etc.)
Organizational Costs (attorney, apostille, Fedex, etc.)
Management Fees (Consultants)
Misc. Expense
Contingency @ 5%
Taxes

G.2 Variable Costs

Locomotive Lease
Locomotive Maintenance
Wagon Lease
Wagon Maintenance
Energy - Netherlands
Energy - Belgium
Energy - Germany
Energy - Poland - Wroclaw (Return)
Energy - Poland - Posnan (Return)
Terminal Charges
Locomotive Change - NL to Germany (Bad Bentheim)
Locomotive Change - Germany to NL (Bad Bentheim)
Locomotive Change - BE to Germany (Aachen)
Locomotive Change - Germany to BE (Aachen)
Locomotive Change - Poland to Germany (Frankfurt am Oder)
Locomotive Change - Germany to Poland (Frankfurt am Oder)
Path Costs - Rotterdam-Oldenzaal Grens (Bad Bentheim)
Path Costs - Oldenzaal Grens (Bad Bentheim) - Rotterdam
Path Costs - Bad Bentheim - Frankfurt am Oder
Path Costs - Frankfurt am Oder -Bad Bentheim
Path Costs - Kunovice (Frankfurt am Oder) - Wroclaw
Path Costs - Wroclaw - Kunovice (Frankfurt am Oder)
Path Costs - Antwerp - Aachen
Path Costs - Aachen - Antwerp
Path Costs - Aachen - Frankfurt am Oder
Path Costs - Frankfurt am Oder - Aachen
Labor - Operating Personnel - Rotterdam-Oldenzaal Grens (Bad Bentheim)
Labor - Operating Personnel - Oldenzaal Grens (Bad Bentheim) - Rotterdam
Labor - Operating Personnel - Bad Bentheim - Frankfurt am Oder/Kunovice

Labor - Operating Personnel - Frankfurt am Oder/Kunovice - Bad Bentheim
Labor - Operating Personnel - Kunovice - Wroclaw
Labor - Operating Personnel - Wroclaw - Kunovice
Labor - Operating Personnel - Antwerp (Combinant) - Aachen
Labor - Operating Personnel - Aachen - Antwerp (Combinant)
Labor - Operating Personnel - Aachen - Frankfurt am Oder/Kunovice
Labor - Operating Personnel - Frankfurt am Oder/Kunovice - Aachen
Labor - Operating Personnel - Frankfurt Oder/Kunowice - Wroclaw
Labor - Operating Personnel - Wroclaw - Frankfurt Oder/Kunowice
Trucking Charges - Forst to Wroclaw (from Rotterdam)
Trucking Charges - Wroclaw to Forst (to Rotterdam)
Trucking Charges - Forst to Wroclaw (from Antwerp)
Trucking Charges - Wroclaw to Forst (to Antwerp)
Operating Personnel - Administrative
Insurance, Locomotive
Insurance, Wagons
Demurrage / Detention (for Wagons)
Rolling Stock Storage
Special Trains
Stand-by/ Overtime
Special / Switching Crew
Line Haul Contractors
Other

Appendix H: List of Delphi Resources and Inputs

Organization	Resource	Country	Type	Context
Baltic Rail Express	Steven Archer, Managing Director	Estonia	Logistics/Freight Forwarder	Development of intermodal traffic between Poland, Germany and the Ports of Antwerp and Rotterdam
Blackwell Industrial Authority	Jeff Seymour, Executive Director	United States	Railway Undertaking	Assessment & physical and business evaluation of Ex-Santa Fe freight line between Wellington KS and Blackwell OK to operate as a viable shortline & development business plan.
City of Fitchburg & Oregon Wisconsin	City Councils of both cities	United States	Prospective Railway Undertaking	Full evaluation of physical condition, funding, traffic prospects and business plan for start of operations of former Chicago & Northwestern Railway line between Evansville WI to Madison WI.
Cudahy Wisconsin	City Council and Mayor	United States	Prospective Railway Undertaking	Establishment of commuter rail passenger service to serve the City of Milwaukee Summerfest

				events, plus become a portion of a new commuter rail route to Kenosha Wisconsin to connect with Metra Commuter Rail of Chicago.
East Side Rail LLC	Douglas Engle, CEO	United States	Railway Undertaking	Developed a plan for inland terminal routing container traffic from the Port of Seattle to industrial district in Bellevue WA and additional local traffic development. (This principal is the basis of the new BNSF inland intermodal facility in Barstow California to/from the Port of LA/Long Beach)
East Troy Railway Company	Chief Counsel, Board member(s) & Chairman, President and Vice President	United States	Railway Undertaking	Established and developed a case for transload facility, line extension, preparations for commencement of freight services, working

				with Canadian National Railway & the Wisconsin Department of Transportation & Walworth County.
ETP, Ltd.	Dr. J. Lee Hutchins, Jr., Principal	United States	Freight transportation planning and development.	Reviewed PowerPoint slide decks for the PhD presentations & various lecturing engagements. He willingly shared his professional experiences, as well as insights from his personal PhD quest.
Glenn Olsen A/S	Glenn Olsen Managing Director	Denmark	Prospective venture	Danish Container Haulage, & for Bring (Norway) & DSV on different routes, both national in Denmark, & between Denmark & Germany - Holland, using the Port of Hirtshals in Denmark.
Heniff Transportation Systems	Michael A. Hansen, Chief Financial Officer	United States	Trucking, bulk transfer	Overview perspective of bulk transfer movements to/from rail connections to/from customers.

Heniff Transportation Systems	Justin Neal, Vice President of Pricing & Analytics	United States	Trucking, bulk transfer	Perspective and detail on how the firm conducts sensitivity analyses for optimal pricing strategies, industry sector observations, views on the relationships with the railroads.
Nordliner GmbH	Dr. Bernd Seidel, Managing Director	Germany	Railway Undertaking	Discussions of establishing a JV for developing intermodal and conventional traffic between Northwestern Germany & Poland (Wroclaw, Oświęcim & Posnan), & other points in Germany, as well as to/from Denmark, as both a transit country (from Sweden) & originating & terminating traffic. Also from investment & evaluation perspective.
Rail Polska Z.o.o.	Edward A. Burkhardt, Chairman and CEO of RailWorld, Inc. (Holding company)	Poland & US	Railway Undertaking	Discussions of developing intermodal traffic between Poland (Wroclaw, Oświęcim & Posnan), & points in Germany, as well as

				linking to the Ports of Antwerp and Rotterdam
St. Kitts Railroad	Thomas Rader, CEO	St. Kitts/Nevis	Railway Undertaking	Evaluated railway for possible shift from tourist passenger to re-establishing freight from defunct sugar traffic, search for narrow gauge locomotives from Finland & Poland as replacements and backups.
Tågåkeriet i Bergslagen AB	Lars Yngstrom, CEO	Sweden	Railway Undertaking	Discussions of establishing a JV for developing intermodal & conventional traffic (steel) between Poland (Wroclaw, Oświęcim & Posnan), & points in Germany, as well as linking to the Ports of Antwerp & Rotterdam, through Denmark, as both a transit country & originating & terminating traffic.
Trucking - ACME Transportation Co.	Tracy Davis, President & CEO	United States	Trucking company	Perspective of trucking & drayage operator moving

				containers and trailers to/from railroad intermodal facilities & general sector knowledge.
United Rail, Inc.	Michael Barron, CEO	United States	Shortline RR Consolidator	Developing shortline acquisition targets, evaluation & M&A steps. Full evaluation of New England Southern RR.
United Rail, Inc.	Edward M. Berntsen, Chief Engineer	United States	Shortline RR Consolidator	Worked with him closely for physical evaluation, traffic generation prospects, work with state departments of transportation, regulatory matters, taxation, operations & mechanical. Extensive shortline experience.
United Rail, Inc.	Louis M. Schillinger, President	United States	Shortline RR Consolidator	Liability insurance and risk exposures

Table H- 1: Table of Delphi Resources and Inputs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