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A road map for explorative scenario creation on Belgian rail freight transport development

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Abstract

The starting point of this paper is the weak usage of rail freight in Belgium and Europe, both as a sustainable mode of land transportation in itself, as well as a part of the intermodal chain. The results are obtained by transversal research on rail freight transportation in Belgium, taking into account the European context. The interdisciplinary research develops three integrated scenarios, a best case, medium case and worst case scenario for rail freight development, based on a detailed SWOT analysis. It includes the most probable future developments for rail freight transport, the intermodal chain and the hinterland connections. These developments are obtained from literature review and discussions with a heterogeneous panel of experts in the field of optimal corridor and hub development; macro-economic impact; sustainability; effective market regulation; and governance and organization for a well-functioning intermodality. Developing the SWOT and scenarios, the Delphi approach is used in combination with a survey analysis. Frequency tables and the H-index allow defining a ranking of selected SWOT elements, allowing for differentiation during the creation of the scenarios.

Keywords: Brain-Trains; Rail freight; SWOT analysis; Scenario analysis; Delphi technique; Survey

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1. Introduction

Over the last decades, road transportation has become the dominant mode of land transportation on the European continent. In order to achieve a more sustainable balance between existing modes of hinterland transportation, the European Commission (2011) established determined yet ambitious goals in its White Paper. Making an attempt to encourage and improve the use of more sustainable modes of transport such as rail transport and inland waterways (IWW), the Commission has the intention to reduce the dominant share of road transportation in Europe. By 2030, the ambition is to decrease the share of road transportation by shifting 30% of the current transport flows over 300 km from road towards more sustainable ways of transportation. It is anticipated in the White Paper that the shift will reach 50% by 2050. To obtain its ambitious goals, the White Paper (European Commission, 2011) also foresees in the development of a European Single Transport Area, which is intended to create efficient and attractive rail and waterborne transportation by providing optimal connections and an improved interoperability between the existing modes of land transportation.

Taking into account the above, the situation of freight transportation in Belgium can be analyzed. Road freight transportation is securing a dominant position in terms of ton-kilometers (tkm) with an estimated market share of 64.5% in 2012. IWW and rail freight transportation are lagging behind with a market share of 20.9% and 14.7% (Eurostat, 2014). Nevertheless, the importance of rail freight transport for ports is indicated by the 71.3% share of rail traffic generated by freight flows from and towards the Flemish ports (Merckx and Neyts, 2013). This relatively weak usage of rail freight transportation was the starting point to perform interdisciplinary research on the role and influences of rail freight in Belgium and offers the opportunity to identify the impact of a changing environment on the development of this transport mode.

This research is done in the BRAIN-TRAINS project, initiated by BELSPO. The project intends to develop a blueprint in which the necessary criteria and conditions for successful rail freight development are established. As such, this model can be used as an operational framework by both rail freight users and decision makers, in order to estimate the impact of future developments and decisions in the field of rail transportation. The transversal analysis is concentrating on five different main subjects:

- Optimal corridor and hub development
- Macro-economic impact
- Sustainability
- Effective market regulation
- Corresponding governance and organization

The current paper is based on the first results of this project, focusing on the development process of scenarios for future rail freight positions. These scenarios will be used in a later stage of the project, to identify the key factors contributing to the development of rail freight transportation and measuring the impact of decisions altering these key factors. The starting research question is whether these scenarios can be developed based on a SWOT analysis indicating the current strengths and weaknesses and the future trends and barriers for rail freight transport. This type of analysis is the result of a study of scientific literature, as well as sectoral information, governmental publications and personal interviews. The development of a SWOT analysis from an interdisciplinary perspective generates scientific, sectorial and policy-related added value. Scientific, because hinterland transport is often focusing on only one mode of transport without taking into account the total logistics chain. Sectorial, since rail transport companies are often working in isolation, establishing little or no cooperation with other transport companies. And finally policy-related, as different policy levels are influencing the development of the rail sector. Next to the European regulation, rail freight is nationally also defined by a federal and regional government in Belgium. The methodology used to perform the SWOT analysis and to transform the validated SWOT into a set of scenarios will be discussed in section 2 of this paper. The resulting SWOT analysis and scenarios are presented and discussed in section 3. A final conclusion is made in section 4.

2. Methodology

Section 2 describes the methodology used to develop the SWOT table, as well as how the analysis on this SWOT was performed and explains the process adopted to develop scenarios from this SWOT and its analysis. Fig. 1. is showing the used road map created for this process. Literature review shows that there is no existing methodology that can be applied to translate a SWOT into quantified scenarios. Therefore this development path is created based on existing tools such as the Delphi technique, which will be discussed in section 2.1. A SWOT survey combined with a statistical analysis of the results is discussed in section 2.2. Section 2.3 focuses on the chosen scenario characteristics and the final phase of the scenario creation.

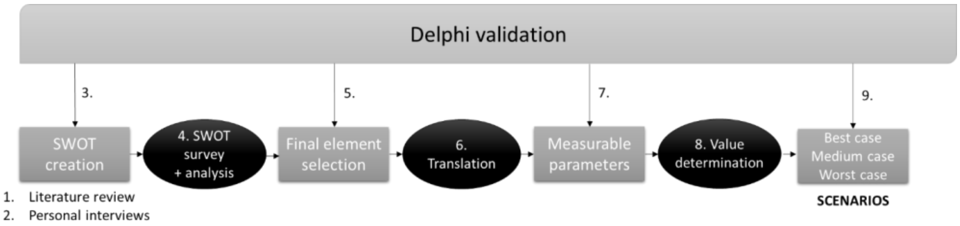


Fig. 1. Road map for scenario development from a SWOT analysis – methodology approach (Troch et al., 2015)

2.1. SWOT creation and Delphi technique

To create the initial SWOT for rail freight development in Belgium and to validate the obtained results, the Delphi technique was used. Kerlinger (1973) states that within such a Delphi exercise, an extensive review of existing literature is the starting point for creating the SWOT. Within this literature review, scientific publications, government studies and sectoral information have been taken into account. Based on Hasson et al. (2000) the results from this literature review were complemented in a second step of the Delphi exercise with qualitative data from personal interviews with field experts. Hsu and Sandford (2007) indicate that in a third step, the Delphi technique can be used to confirm the presented observations by acquiring a consensus within a heterogeneous panel of experts. A draft SWOT, listing the observed possible internal and external factors influencing rail transportation, was therefore presented to such a panel consisting of three port authorities, two rail freight operators including the largest Belgian rail operator holding a market share of 80% (Deville and Verdun, 2012), two government representatives, three academic contributors and four shippers actually using rail transport for freight transportation. The Delphi process itself consists of a number of discussion rounds between the authors and the heterogeneous panel of experts, attempting to overcome different opinions and validate the SWOT results by reaching a general agreement.

This Delphi exercise and its corresponding validation of results is used throughout the continuation of the scenario development process as well. Furthermore, Fig. 1. is showing these different steps in the process where the Delphi technique is applied. After reaching a consensus on the presented SWOT, a SWOT survey was performed in a fourth step. The results of this survey are statistically analyzed in order to obtain a ranking of the different SWOT elements. By applying the Delphi exercise on these survey results and the obtained ranking, a final selection of elements is obtained in a fifth step. The results of this selection will be discussed in section 3.1. In a sixth step, the selected SWOT elements were translated into measurable parameters. These results were again presented to the heterogeneous panel of experts, in light of the used Delphi technique, searching for validation in a seventh step in Fig. 1. After reaching an agreement on the necessary parameters for the scenario creation, reference and scenarios values were determined in step eight in order to create draft scenarios. This process continued to use the Delphi exercise in a final ninth step, requiring a general agreement from the panel of experts on these scenario parameter values before being taken into account in the final scenarios. The final outcome of the developed and applied road map for scenario creation on the Belgian rail freight development will be discussed in section 3.2.

2.2. Survey methodology

In order to select the most important elements of the SWOT, as well as to take into account the likelihood of a concerned element having an impact in the future, a 3-step survey methodology approach is used.

In a first phase, each member of the heterogeneous panel of experts had to rate each validated SWOT element for its influence on rail development and its likelihood of happening on a Likert-scale ranging from 1 to 5, with 1 being no influence or likelihood of happening and 5 being a very high influence or likelihood of happening. In total, 14 respondents participated to the survey.

In a second phase, the ordinal data was analyzed by common statistical parameters. A frequency table shows the distribution of answers over the five different possible scores for each element. The modus is the score with the highest frequency, i.e. the answer which most respondents selected for the concerned question. As such, the SWOT elements can be ranked according to their obtained modus in both categories.

A third phase consists of the calculation of the H-index. This is a relative homogeneity index, indicating the level of agreement between the different respondents on a certain obtained modus. The H-index is calculated as follows, where f_{ij} indicates the percentage of respondents that score an element i with Likert-scale value j (Acciaro et al., 2013):

$$h_i = \sum_j f_{ij}^2 \tag{1}$$

$$H_i = \frac{h_i - \min(h_i)}{\max(h_i) - \min(h_i)} \tag{2}$$

Where Eq. 1. is calculating the absolute H-index, Eq. 2. is calculating the relative value expressed in a percentage. Maximum homogeneity, and as such a maximum level of agreement between the respondents, is reached when h_i equals 1 and Hi equals 100%. In case Hi equals 0%, maximum heterogeneity is reached, indicating respondents disagree on an obtained modus and answer frequencies for the concerned element are spread equally over the Likert scale. In order to find the most important elements for rail transport development, an additional ranking can be performed looking for elements with a modus indicating a high influence and a high likelihood of happening, and the highest level of agreement on these obtained modes. This approach corresponds to the methodology of Crozet (2003) shown in Fig. 2. This figure indicates which variables are crucial to be taken into account for scenario creation. First, scenario elements are to have a high importance, determining them as structural elements. Elements with a low importance are not recommended to be taken into account for scenario creation. Secondly, the level of control of the elements needs to be determined, which can be linked to the likelihood of happening. For scenario development preference is given to the elements with a weak level of control, defining them as explorative factors or identified trends depending on the level of uncertainty. In case the level of control is high, elements can be identified as strategic factors or decision makers.

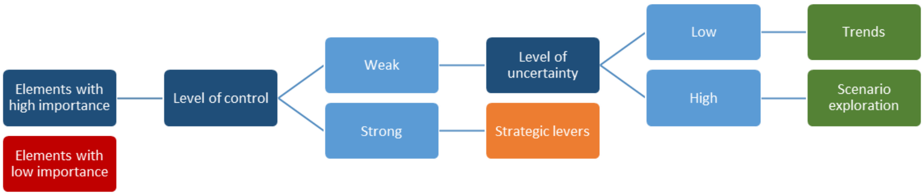


Fig. 2. Framework for element selection in scenario development based on Crozet (2003)

According to the Delphi methodology from section 2.1, the results of this exercise were againpresented to the heterogeneous panel of experts, in order to define a final selection of SWOT elements that can be taken into account for further research. The results of this process and the final selected SWOT elements will be discussed in section 3.1.

2.3. Scenario creation and characteristics

The validated SWOT elements obtained by the methodology explained in section 2.1 and section 2.2 were transformed into a set of measurable parameters, and used as input for the continuation of the Delphi exercise shown in Fig. 1. The objective of these scenarios is to identify the possible impact of decisions and developments in rail freight transportation in Belgium. Based on the definitions of the European Commission (2007), Lobo et al. (2005) and Kahn and Wiener (1967), a scenario is defined in this research paper as “an exploration of hypothetical future events, highlighting the possible discontinuities from the present and used as a tool for decision-making”. The scenarios presented are therefore a collection of plausible future events, respecting consistency between different elements selected in each scenario, but without attempting to forecast their exact nature or to predict the future. Therefore the validation obtained from the panel in the Delphi exercise is of crucial importance.

After validation of the proposed parameters for scenario creation, based on the approved SWOT elements, reference values and scenario values are defined. Reference values are obtained for the period 2010 to 2015, while scenario values are taking into account a scenario horizon of 2030, the first milestone of the White Paper of the European Commission (2011). Due to the explorative character of the developed scenarios, a wide range of scenario values was explored, resulting in three widespread scenarios: a best case, a medium case and a worst case scenario for rail freight development.

3. Results and discussion

The methodology described in section 2 results in a number of validated outputs that are presented and discussed in this section. The first rounds of the Delphi process, combined with a survey analysis, created a final and validated SWOT for rail freight development, which will be discussed in section 3.1. The continuation of the Delphi process results in the creation of three explorative scenarios, containing plausible future developments impacting future rail freight transport. This will be discussed in section 3.2.

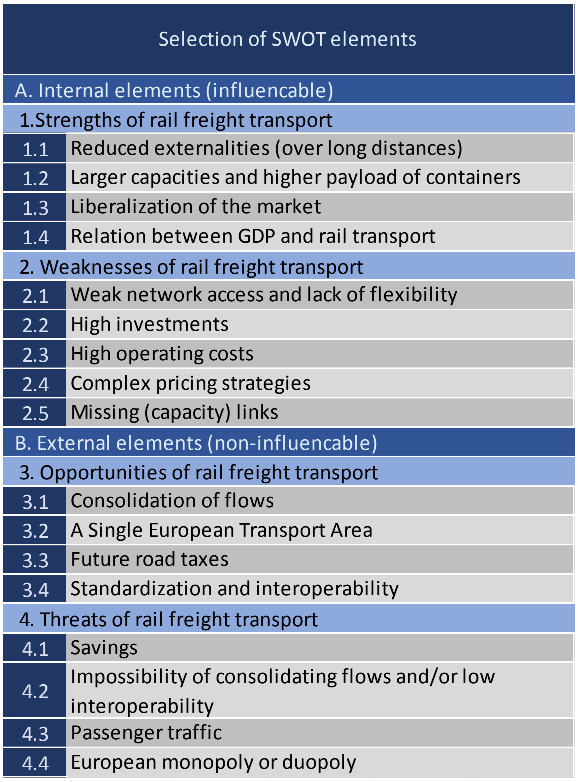
3.1. SWOT

Out of the original literature review, 93 SWOT elements were identified (Vanelslander, 2015). These elements have been used as input for the Delphi exercise and the SWOT survey. Analysis of this process has led to 17 final SWOT elements, unanimously agreed upon by the heterogeneous panel of experts. These elements are shown in Fig. 3. and subsequently will be briefly explained, focusing on respectively the identified strengths, weaknesses, opportunities and threats.

3.1.1. Strengths

Externalities, the first strength in Fig. 3., are costs generated by the development of infrastructure, accidents, congestion and the emission of noise and air pollutants. External costs arise for all modes of transportation. However Grosso (2011) and Fries and Hellweg (2014) observed rail transportation to be a more sustainable mode of transport compared to road transportation, due to it low marginal external cost factor on long-haul distances (Kreutzberger et al., 2003). Subsequent to the increasing social pressure on governments to internalize the external costs of transportation, this element is a strength for rail freight transportation.

A second strength of rail transportation is the possibility of offering larger capacities and a higher payload of containers. This results in economies of scale, reducing the cost of the total logistics chain when rail transportation is used as main mode of land transportation (Rodrigue et al., 2006).



Selection of SWOT elements	
A. Internal elements (influencable)	
1.Strengths of rail freight transport	
1.1	Reduced externalities (over long distances)
1.2	Larger capacities and higher payload of containers
1.3	Liberalization of the market
1.4	Relation between GDP and rail transport
2. Weaknesses of rail freight transport	
2.1	Weak network access and lack of flexibility
2.2	High investments
2.3	High operating costs
2.4	Complex pricing strategies
2.5	Missing (capacity) links
B. External elements (non-influencable)	
3. Opportunities of rail freight transport	
3.1	Consolidation of flows
3.2	A Single European Transport Area
3.3	Future road taxes
3.4	Standardization and interoperability
4. Threats of rail freight transport	
4.1	Savings
4.2	Impossibility of consolidating flows and/or low interoperability
4.3	Passenger traffic
4.4	European monopoly or duopoly

Fig. 3. Final selection of 17 SWOT elements impacting rail freight development (Vanelslander et al., 2015)

Liberalization of the Belgian rail freight market has started since 2005 and is organized from the European level in order to increase market competition. This process is seen as the third strength for rail freight. It is intended that the outcome of this process will increase the efficiency and effectiveness, as well as the attractiveness of rail freight transport due to the expected increase in service-levels in the long run. Similar results have been obtained by the liberalization of other sectors (Paardenkoper, 2009). Crozet et al. (2014) also developed a Rail Liberalization Index, indicating the degree of liberalization compared to other European countries. By 2014, Belgium was positioned in the upper middle class of this index. However, it is worth to mention that meanwhile in 2015 the incumbent rail operator B-logistics received a capital increase by the private investor Argos Soditic, acquiring 68.9% of the company’s capital, loosening the ties with the state owned rail company SCNB logistics (B logistics, 2015).

A final strength exists in the positive relationship between economic growth and transport growth. Due to its beneficial position within the ‘Blue Banana’, a European region with high population density and high economic activity, 5 to 8 % of the Belgian Gross Domestic Products (GDP) is defined by the logistics sector (European Commission, 2006). In addition, this positive correlation is working in both ways. An expected economic recovery has a clear impact on the demand of logistics and as such rail transportation, while an increase in logistic activities also contributes to the growth of the GDP itself. Although this relationship has faced a certain trend of decoupling over the past decades, these two factors still remain positively correlated (Meersman et al., 2013).

3.1.2. Weaknesses

Fig. 3. is listing the five selected weaknesses of rail freight transportation. Weak network access and a lack of flexibility has been identified as main weakness, with a maximum level of agreement between the heterogeneous panel of experts on its high impact and likelihood of influencing the future rail freight development. It is clear that access to the rail network is lower compared to road transportation. Roads are more commonly available, increasing the number of alternative routes and as such flexibility; and access to roads is less restricted compared to rail transportation where a high number of conditions need to be fulfilled and permits need to be obtained before being allowed to access and operate on the rail network itself. In addition, flexibility of rail freight transportation is lower compared to road transportation due to a number of reasons such as the priority rules for passenger traffic using the same network (Crozet et al., 2014), the need for high distances and high volumes, low interoperability, low rail punctuality and a time-consuming process for ordering rail slots (Grosso, 2011; Vandressen et al., 2012). The weak network access can also be explained due to the high investments that are required to start operations (Pham, 2013).

Other weaknesses are the high operating costs and complex pricing strategies. Janic (2007) identifies operating costs as the charges applied for moving units from shippers to receivers, including collection, distribution, line hauling and transshipment. Rail freight transport is experiencing this factor as a weakness due to the requirement of a higher break-even distance compared to road transportation, rendering it only efficient on long-haul traffic flows. Complex pricing strategies make it difficult for shippers to compare possible transport mode alternatives. Bontekoning et al. (2014) indicate that this complexity is increased by two levels of pricing strategy: the individual actors and door-to-door chain level actors.

A final weakness identified are the missing links in the rail network. According to Schwab et al. (2014), the current Belgian rail infrastructure cannot handle a 50% combined increase of passenger and freight transport. Despite maintaining one of the highest density networks of all European countries with over 3.500 km of rail tracks, many rail connections are in poor condition, have been abandoned or are even dismantled over the past decades (Vannieuwenhuyse et al., 2006).

3.1.3. Opportunities

Next to the strengths and weaknesses, Fig. 3. is also listing a number of trends and barriers that could influence the future development of rail freight transportation. A first opportunity identified is the consolidation of flows. Crozet et al. (2014) and Mitusch et al. (2014) stress the importance of intermodal transport in the future, and the role of rail transport as a major player in the corresponding hinterland transport. As such, increased bundling opportunities will arise in multimodal freight terminals, where flows are combined and switched from one mode of transportation to another. This trend could therefore increase attractiveness and efficiency of rail transportation, positively impacting its future development.

Also the Single European Transport Area, one of the action steps taken by the European Commission (2011) to reach the goals of the White Paper, is seen as an opportunity to decrease costs due to the benefits of an expanding unified market. Within the Trans-European Transport Network (TEN-T), nine different main rail freight corridors (RFC) are developed, connecting the different corners of the European continent. Three of these key corridors are crossing Belgium and are connecting the Flemish ports to the different hinterland destinations across Europe. In this respect, the growth of Central and Eastern Europe’s economies can be incorporated in the growth of European rail freight (Mitusch et al., 2014).

As of April 2016, trucks will be charged for each kilometer performed on Belgian motorways. This internalization of external costs will decrease the attractiveness of road transportation and benefit rail transport as a suitable alternative (UTPR, 2015).

A final but very important opportunity identified by the Delphi exercise, is the expectancy of an increased standardization within the rail sector and improved interoperability with other modes of transport. Due to the high life-cycle of equipment and rail infrastructure, innovation is entering very slowly and geographically spread (Mitusch et al., 2014). Although technological inventions such as coherent chassis and superstructures already make it possible to switch easily from one mode of transport towards another, and research and development is making this process more efficient every day, the introduction on the field is taking a long time. Therefore, this opportunity is identified at the same time as a major threat (Bulc, 2014). In addition, the rail sector has long been dominated by national operators and rail networks are managed by national infrastructure managers and national regulation, resulting in dissimilar standards in the different European countries. This contradicts the increasing trend of globalization and the long distance condition for rail transportation in order to become profitable, as this requires cross-border rail traffic on the European continent. This lack of standards and the differences in regulation requirements are creating border-bottlenecks (Crozet et al., 2014). The efforts of the European Commission to create a European level of regulation and a Single European Transport Area has been positively welcomed by the rail sector, believing in the opportunity this could bring for its further development. Within the European rail freight corridors, the ultimate goal is to use the same staff and equipment, lifting the existing bottlenecks and increasing the efficiency and attractiveness of European rail freight transport, as well as network reliability. Nevertheless, at the same time, a failure of this policy or a lack of implementation on the field poses a clear threat.

3.1.4. Threats

Apart from opportunities not materializing, posing an existing threat for rail freight development, as it is mentioned in section 3.1.3 above, three other threats are identified as a risk for the future of rail transportation. First of all, the current climate of savings and budget cuts might result in the delay or cancellation of infrastructure projects and investments (Mobiliteitsraad, 2012). Public investments have declined by 20% and also the Belgian infrastructure manager has to cut back on 20% of the budget by 2020 (INFRABEL, 2014). Additionally, subsidies for rail freight transport in Belgium have declined over the past years from 30 million euros in 2007 to only 15 million euros in 2014 (Santos et al., 2015).

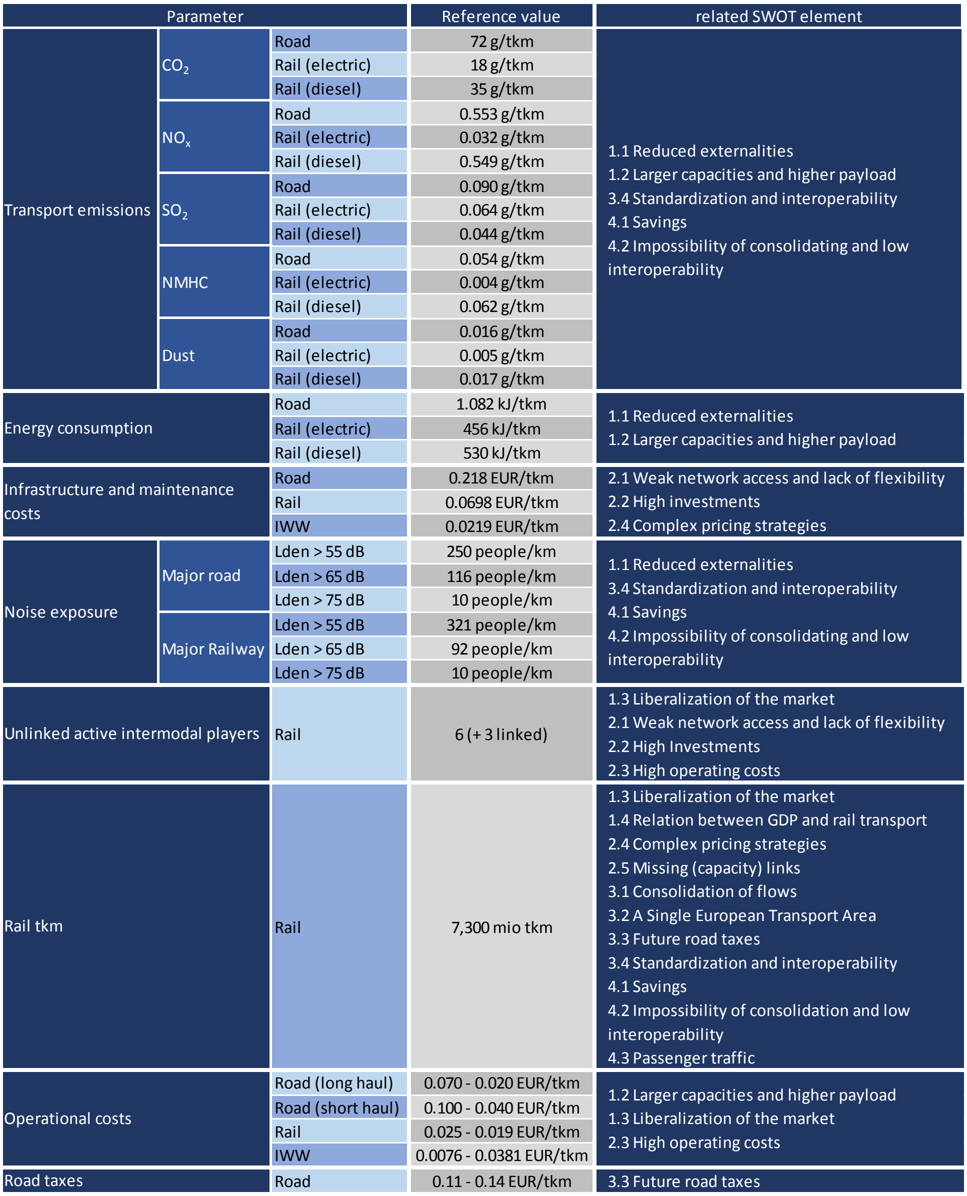
A second threat is the interference of increasing passenger traffic on the same rail network. Due to road congestion, trains are becoming more attractive for commuter traffic, pressuring the available capacity for rail freight transportation. This is also indicated by Deville and Verduyn (2012), showing an increase of passenger-kilometers by 60% over the period 1990-2012. If this trend continues, this could pose a real threat for the development of rail freight transportation.

The last threat identified and approved by the panel of experts, is the trend towards a European duopoly or even a monopoly. Van de Voorde and Vanelslander (2014) investigated the European liberalization and possible regulation effects on the future development of rail transportation in Belgium. They conclude with three possible scenarios, being an unchanged market structure, a de facto monopoly and a de facto duopoly, which they consider to be the most likely evolution of the Belgian market, with room for a number of smaller railway operators. However, it should be taken into account that this study has been performed before the private capital investment in B Logistics by Argos Soditic. During the Delphi exercise, the panel of experts also indicated that the evolution towards a de facto monopoly or duopoly might impose an important threat, however the extent or impact of this evolution remains unclear.

3.2. Scenarios

Based on the final SWOT elements and the process described in the methodology in section 2, a number of measurable parameters are linked to the different identified SWOT elements (Troch, 2015). These parameters are used to explore three widespread scenarios, incorporating possible future developments of rail freight transportation in Belgium and the influence by the European context. In order to improve comparability, a reference value for each parameter has been identified. The results of this process are presented in Fig. 4. The final selected parameters are linked to the corresponding 17 identified SWOT elements explained in section 3.1. The linked reference values are based on a literature review and sectoral information and approved as well by the heterogeneous panel of experts in the Delphi exercise discussed in section 2.

The ECOTRANSIT (2008) study is used to define a reference value for the first two parameters, being the transport emissions and energy consumption. This study calculates average values for 20 European countries, including Belgium. It can be seen in Fig. 4. that rail transportation is currently far more sustainable compared to road transportation, especially when electric driving is used. Emission factors of electricity production are also taken into



Parameter			Reference value	related SWOT element
Transport emissions	CO_2	Road	72 g/tkm	1.1 Reduced externalities 1.2 Larger capacities and higher payload 3.4 Standardization and interoperability 4.1 Savings 4.2 Impossibility of consolidating and low interoperability
		Rail (electric)	18 g/tkm	
		Rail (diesel)	35 g/tkm	
	NO_x	Road	0.553 g/tkm	
		Rail (electric)	0.032 g/tkm	
		Rail (diesel)	0.549 g/tkm	
	SO_2	Road	0.090 g/tkm	
		Rail (electric)	0.064 g/tkm	
		Rail (diesel)	0.044 g/tkm	
	NMHC	Road	0.054 g/tkm	
		Rail (electric)	0.004 g/tkm	
		Rail (diesel)	0.062 g/tkm	
	Dust	Road	0.016 g/tkm	
		Rail (electric)	0.005 g/tkm	
		Rail (diesel)	0.017 g/tkm	
Energy consumption		Road	1.082 kJ/tkm	1.1 Reduced externalities 1.2 Larger capacities and higher payload
		Rail (electric)	456 kJ/tkm	
		Rail (diesel)	530 kJ/tkm	
Infrastructure and maintenance costs		Road	0.218 EUR/tkm	2.1 Weak network access and lack of flexibility 2.2 High investments 2.4 Complex pricing strategies
		Rail	0.0698 EUR/tkm	
		IWW	0.0219 EUR/tkm	
Noise exposure	Major road	Lden > 55 dB	250 people/km	1.1 Reduced externalities 3.4 Standardization and interoperability 4.1 Savings 4.2 Impossibility of consolidating and low interoperability
		Lden > 65 dB	116 people/km	
		Lden > 75 dB	10 people/km	
	Major Railway	Lden > 55 dB	321 people/km	
		Lden > 65 dB	92 people/km	
		Lden > 75 dB	10 people/km	
Unlinked active intermodal players		Rail	6 (+ 3 linked)	1.3 Liberalization of the market 2.1 Weak network access and lack of flexibility 2.2 High Investments 2.3 High operating costs
Rail tkm		Rail	7,300 mio tkm	1.3 Liberalization of the market 1.4 Relation between GDP and rail transport 2.4 Complex pricing strategies 2.5 Missing (capacity) links 3.1 Consolidation of flows 3.2 A Single European Transport Area 3.3 Future road taxes 3.4 Standardization and interoperability 4.1 Savings 4.2 Impossibility of consolidation and low interoperability 4.3 Passenger traffic
Operational costs		Road (long haul)	0.070 - 0.020 EUR/tkm	1.2 Larger capacities and higher payload 1.3 Liberalization of the market 2.3 High operating costs
		Road (short haul)	0.100 - 0.040 EUR/tkm	
		Rail	0.025 - 0.019 EUR/tkm	
		IWW	0.0076 - 0.0381 EUR/tkm	
Road taxes		Road	0.11 - 0.14 EUR/tkm	3.3 Future road taxes

Fig. 4. Parameter selection and reference scenario (Troch, 2015)

account. The observed values have been validated by the TREMOVE study (Ricardo-AEA et a., 2014), data published by the European Environment Agency (2013) and a spot-check performed based on data from the incumbent and to date still largest Belgian rail operator over the period 2006 to 2012. Final approval was obtained during the different rounds in the Delphi exercise. The exploration of sustainability parameters is mainly linked to the SWOT elements concerning technological evolution, standardization and the necessary conditions to benefit from economies of scale such as large capacities, high payloads and long distances.

For the parameter on infrastructure and maintenance cost, only the cost of building and maintaining the infrastructure is taken into account. The complex system used for access charges is not taken into consideration. The reference values are obtained from the study of CE Delft et al. (2010) and show the cost advantage of rail transportation and IWW over road transportation.

Data on noise exposure is scarce. Therefore, a calculation was made based on the data of Flanders for 2012. The parameter values are showing the number of people exposed to noise disturbance during the day, evening and night period (L_{den}), for both major roads and railways. The values are expressed in decibels (dB). Although considered to be a sustainable mode of transport, noise disturbance is still considered to be a weak link for rail transportation. The evolution of this parameter will be highly dependent on technological evolutions (European Commission, 2002; Hurtley, 2009).

For the number of market players, public data from the Belgian infrastructure manager INFRABEL is used. This parameter will take into account the SWOT element on a possible de factor monopoly or duopoly for the Belgian rail market, as discussed in section 3.1.4.

The rail demand is obtained from the statistical pocket book of the European Commission (2014). The importance of this value is reflected in the multiple links with the final selected 17 SWOT elements. Rail demand is therefore to be considered a key parameter in the exploration of possible future states for rail freight in Belgium and linked to many other parameters and factors involved in the development of the final scenarios.

The operational cost values for road and rail transport are obtained from a the study of Janic (2008). The values for inland waterway transportation are calculated by PWC (2003).

The final parameter used for scenario exploration is the future development of road taxes. As from April 2016, the current Eurovignette will be replaced by a charge per tonkilometer for trucks heavier than 3.5 tons (Viapass, 2015).

In the next sections, we will discuss the exploration of three possible scenarios, based on the selected SWOT elements, the approved parameters and the corresponding reference values discussed in the sections above. Each scenario is the result of a discussion with the panel of experts according to the Delphi exercise described in section 2.2.

3.2.1. Best case scenario

The best case scenario is shown in appendix A.1. This scenario takes into account the objective of a 30% shift from road transportation over 300 km to rail transport and IWW being realized by 2030. Within this scenario, technological developments and investments in research and development are expected to increase the environmental sustainability of rail transportation, while improved standardization and interoperability can make it more flexible and therefore an attractive alternative to inland transportation in the future. The estimated increase in rail demand by 133% is obtained from the discussion with the heterogeneous panel of experts and studies by Vandresse et al. (2012) and Islam et al. (2013). These studies investigate the necessary increase of rail transportation in Belgium, taking into account the forecasted transport demand by 2030 as well as the needed increase to realize the earlier discussed shift from road transport over 300 km which is set in the White Paper (European Commission, 2011).

Within the best case scenario, rail transport is also expected to lower its direct emissions by 40%. Although it is expected that road transportation will also become more sustainable thanks to technological evolutions, indicated by the emission decrease by 20%, rail transport is given a greater advantage within this explored scenario, thus improving its position. The same conclusions are made for the energy consumption, infrastructure and maintenance and operational costs involved in the different modes of hinterland transportation. This decrease for all modes of hinterland transportation strengthens the opportunities for intermodal transportation to become a key factor for rail freight development in the future. The reason for this can be found in the total decrease of the cost of the full chain of logistics, where rail can be used as the main mode of transportation in the intermodal chain, and road transportation for pre – and post haulage (Crozet et al., 2014).

In order to increase efficiency and as such attractiveness within the rail sector, market competition is expected to increase as well, resulting in an increase in independent market players from six to ten rail operators offering rail freight services on the Belgian rail network.

The imposed road taxes on the Belgian highway network are explored to increase by 20% in the best case scenario. As such, a continued internalization of external costs impacts the attractiveness of rail freight transportation as a considerable transport option for shippers.

3.2.2. Worst case scenario

The worst case scenario is the complete opposite of the best case scenario and is presented in appendix A.2. Transport demand grows more slowly than expected and no specific measures are taken to stimulate or develop rail freight transportation. Consequently, no shift from road transportation over 300 km is achieved and road transport increases its dominant position on the market. This results in a rail demand of 8,000 million ton kilometers, an increase by only 10%. The scenario is started from the reflection that the delay and cancellations of crucial investments are holding back standardization. This results in a continuation of the currently weak interoperability and as such a low level of flexibility and attractiveness of rail freight transportation.

In a worst case scenario where technological advantages are held back due to the continuing climate of savings and budget cuts, rail transport is also losing its advantageous position in terms of sustainability compared to road transportation. Pushed by the public opinion and helped by private investments, road transportation is becoming cleaner more rapidly, resulting in a drop in emission values by 40%, compared to a decrease of only 10% for rail transportation. The same conclusions can be made for energy consumption and infrastructure, maintenance and operational costs. Due to the lack of volume, no consolidation can be obtained and additional economies of scale are not obtained. Also the market competition is expected to decrease within this scenario, analyzing the possible impact of a de facto monopoly or duopoly.

3.2.3. Medium case scenario

The medium case scenario is a mix of elements from the previous two scenarios, shown in appendix A.3, with rail freight and IWW acquiring a partial shift from road transportation over 300 km. This results in a rail demand of 12,000 million ton kilometers, reflecting a rise by 64%. Within this scenario, a certain level of standardization is expected to come true. Together with a continuation of the most crucial planned investments, interoperability is expected to improve as well, resulting in increased flexibility and a higher service level of rail transportation, increasing its attractiveness.

Within this scenario, road and rail transportation are expected to benefit at a similar rate from possible technological advancements. Therefore rail transportation is keeping its preferred position as a sustainable mode of transportation, compared to road transport. The same observations can be made for the energy consumption and the infrastructure, maintenance and operational costs.

Taking into account the three possible scenarios from Van de Voorde and Vanelslander (2014), the third scenario is reflecting on the possibility of a rail freight sector dominated by a limited number of market players.

4. Conclusion

The main conclusion from the paper is that scenarios can indeed be developed based on a SWOT analysis. In order to do so, a road map has been developed based on the case of rail freight transport development in Belgium, also taking into account the European context for this sector. This paper revealed and discussed findings from the ongoing interdisciplinary research in this field, with special attention given to the position of rail freight transport as an attractive alternative of land transportation, compared to its direct competitors being road transportation and IWW. The starting point is the weak usage of rail freight to reach hinterland destinations, despite its favorable position as a sustainable mode of transport and obtainable economies of scale for combined transport flows on long distances.

To get a clear overview on the current situation of rail freight transportation in Belgium, and by extension also the European context, a SWOT overview has been built. Next to personal interviews and an extensive literature review, in which both scientific and sectoral information has been taken into account, the result of the SWOT has been validated by the use of the Delphi technique. Within this process, a heterogeneous panel of experts discusses in multiple rounds the presented results and need to reach a general agreement on the validity of the different elements. In case no agreement is reached on a certain point, it cannot be taken into consideration for further analysis. As such, only elements that receive validation by the full panel of experts are used as an input in the next process of the Delphi exercise. In total, 17 final SWOT elements have been agreed upon. The main strengths identified for rail freight transportation in Belgium are the reduced externalities, as rail transportation currently is far more sustainable compared to road transportation, and reduced costs due to the possibility of rail transport taking into account larger capacities and a higher payload per container, resulting in economies of scale. Other strengths are the liberalization of the market, increasing competition and as such efficiency, and the relation between economic growth and an increase in transport demand. Current weaknesses of rail transportation are the weak network access, a substantial lack of flexibility offered by rail services towards users of rail freight and the complex pricing strategies used by rail operators, making it difficult to compare possible land transport alternatives. In addition, the high investments and high operating costs make it difficult for new players to enter the market, obstructing the increase of market competition desired by the liberalization. A final weakness are the missing capacity links on the Belgian rail network.

Within the SWOT analysis a number of trends and opportunities for the future development of rail freight transportation were defined as well. The consolidation of flows will prove to be essential for rail freight transport to become profitable. The failure of consolidating traffic flows will lead to a decreased efficiency as the main benefit of rail transportation is found in high volume transportation over long distances. Therefore, the failure to obtain this consolidation is considered to be a major threat for the development of rail freight in Belgium and Europe in general. In order to support these consolidation opportunities and the possibilities of long distances for rail freight transport, European regulation and initiatives are focusing on the development of a Single European Transport Area, combined with research and development in the field of standardization and interoperability. By taking away the current barriers of rail transportation, these initiatives aim for an increase in flexibility and service-level offered towards rail freight users. This evolution is however threatened by the current climate of savings and budget cuts, which might result in the delay or even cancellation of these crucial investments. Another trend identified is the increasing pressure to internalize the external costs for road transportation. Road taxes will decrease the attractiveness of road transportation, generating opportunities for rail transport to realize part of the high desired modal shift. Final threats discussed for rail freight development are the influence of passenger traffic, as both types of rail freight share the same infrastructure, and the possible development of a European monopoly or duopoly.

Based on the SWOT results, a number of plausible future developments for rail transportation are explored. This led to the development of three wide-spread scenarios with a 2030 horizon, ranging from a best case scenario to a worst scenario for rail freight development. The used parameters and values within these scenarios are based on the validated SWOT elements and are in their turn approved by the complete panel of experts in the continued Delphi exercise. Within the best case scenario, the White Paper goal of a 30% shift from road transportation over 300 km to rail transport and IWW is explored to be fully realized. As such, this scenario is discussed from the idea to estimate the effect of this goal on the Belgian rail demand. In addition, the necessary criteria and conditions to fulfill this goal are explored. Technological developments and investments in research and development need to increase the environmental sustainability of rail transportation, while improved standards and a more efficient interoperability can make rail freight transportation more flexible and attractive. Specifically for the Belgian case, a rise in rail demand by 133% was found to contribute to the realization of this modal shift goal. The worst case scenario is exploring the complete opposite of the best case. No additional shift from road transport over 300 km is taken into consideration, and investments to stimulate or develop rail transportation are delayed or cancelled. As such the growth of rail demand in Belgium is limited to 10%. This growth is solely linked to the expected economic growth influencing current existing traffic flows by rail. Within this scenario, the possible effects of a European monopoly or duopoly are also taken into account. The medium scenario is a mix of both positive and negative elements, resulting in a partial shift from road transportation over 300 km towards rail and IWW.

The developed road map for scenario development from a SWOT analysis can be used in other sectors as well. This development process allows future research to explore possible trends and barriers for the development of a certain sector, starting from its current strengths and weaknesses, validated by a heterogeneous panel of experts active within this sector. The results from this paper will also be used in further research on the five different fields of this interdisciplinary research. Each field will use a newly developed, existing or altered methodology to define the possible impact of decisions taken influencing the selected SWOT elements and the parameters used to develop the scenarios. The outcome of the research will be an operational framework with a set of indicators, that can support policy-makers and rail users in devising good rail development strategies, maximizing benefits to users and society in general.

Acknowledgements

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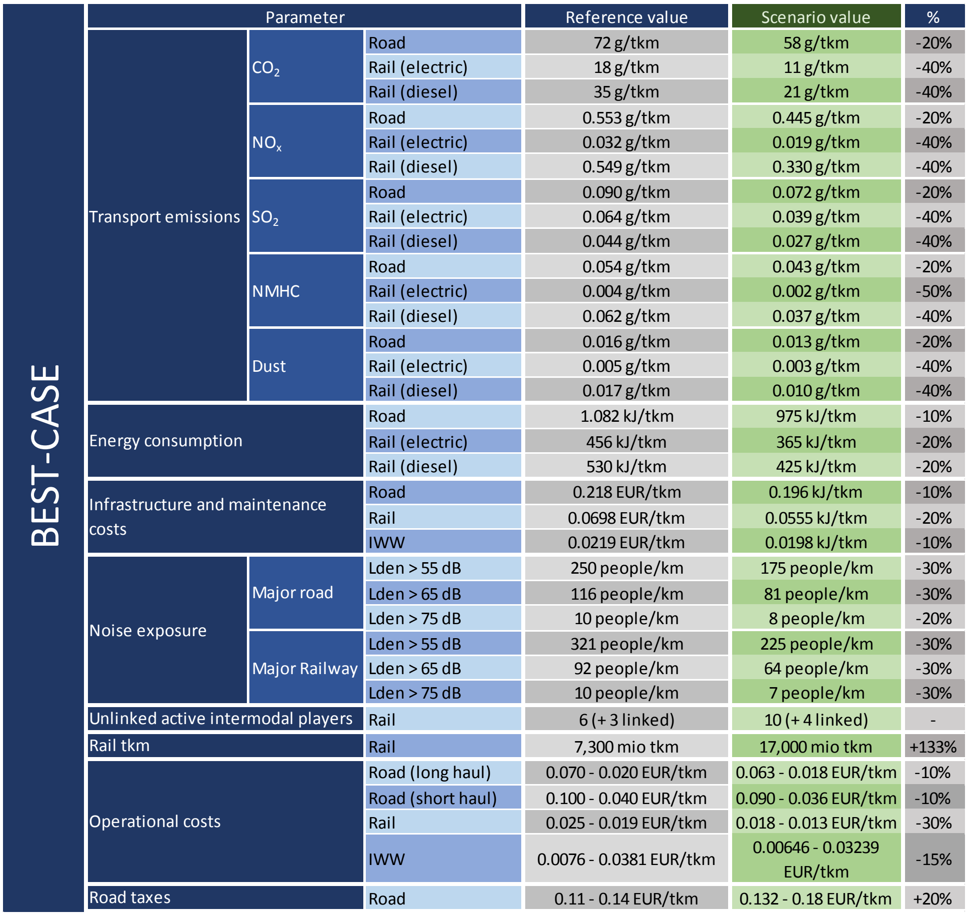
Appendix A. Scenario results

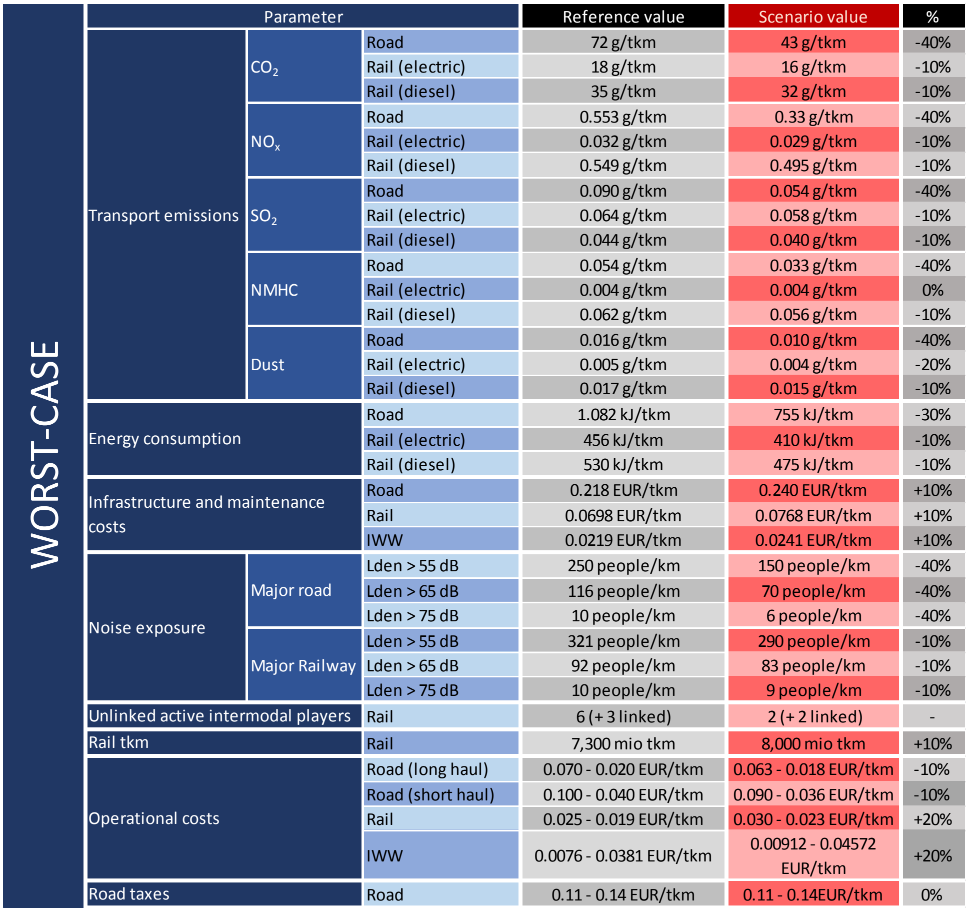
A.1. Best case scenario



	Parameter			Reference value	Scenario value	%
BEST-CASE	Transport emissions	CO_2	Road	72 g/tkm	58 g/tkm	-20%
			Rail (electric)	18 g/tkm	11 g/tkm	-40%
			Rail (diesel)	35 g/tkm	21 g/tkm	-40%
		NO_x	Road	0.553 g/tkm	0.445 g/tkm	-20%
			Rail (electric)	0.032 g/tkm	0.019 g/tkm	-40%
			Rail (diesel)	0.549 g/tkm	0.330 g/tkm	-40%
		SO_2	Road	0.090 g/tkm	0.072 g/tkm	-20%
			Rail (electric)	0.064 g/tkm	0.039 g/tkm	-40%
			Rail (diesel)	0.044 g/tkm	0.027 g/tkm	-40%
		NMHC	Road	0.054 g/tkm	0.043 g/tkm	-20%
			Rail (electric)	0.004 g/tkm	0.002 g/tkm	-50%
			Rail (diesel)	0.062 g/tkm	0.037 g/tkm	-40%
		Dust	Road	0.016 g/tkm	0.013 g/tkm	-20%
			Rail (electric)	0.005 g/tkm	0.003 g/tkm	-40%
			Rail (diesel)	0.017 g/tkm	0.010 g/tkm	-40%
	Energy consumption		Road	1.082 kJ/tkm	975 kJ/tkm	-10%
			Rail (electric)	456 kJ/tkm	365 kJ/tkm	-20%
			Rail (diesel)	530 kJ/tkm	425 kJ/tkm	-20%
	Infrastructure and maintenance costs		Road	0.218 EUR/tkm	0.196 kJ/tkm	-10%
			Rail	0.0698 EUR/tkm	0.0555 kJ/tkm	-20%
			IWW	0.0219 EUR/tkm	0.0198 kJ/tkm	-10%
	Noise exposure	Major road	Lden > 55 dB	250 people/km	175 people/km	-30%
			Lden > 65 dB	116 people/km	81 people/km	-30%
			Lden > 75 dB	10 people/km	8 people/km	-20%
		Major Railway	Lden > 55 dB	321 people/km	225 people/km	-30%
			Lden > 65 dB	92 people/km	64 people/km	-30%
			Lden > 75 dB	10 people/km	7 people/km	-30%
	Unlinked active intermodal players		Rail	6 (+ 3 linked)	10 (+ 4 linked)	-
	Rail tkm		Rail	7,300 mio tkm	17,000 mio tkm	+133%
	Operational costs		Road (long haul)	0.070 - 0.020 EUR/tkm	0.063 - 0.018 EUR/tkm	-10%
			Road (short haul)	0.100 - 0.040 EUR/tkm	0.090 - 0.036 EUR/tkm	-10%
			Rail	0.025 - 0.019 EUR/tkm	0.018 - 0.013 EUR/tkm	-30%
			IWW	0.0076 - 0.0381 EUR/tkm	0.00646 - 0.03239 EUR/tkm	-15%
	Road taxes		Road	0.11 - 0.14 EUR/tkm	0.132 - 0.18 EUR/tkm	+20%

Fig. 5. Best case scenario (Troch et al., 2015)

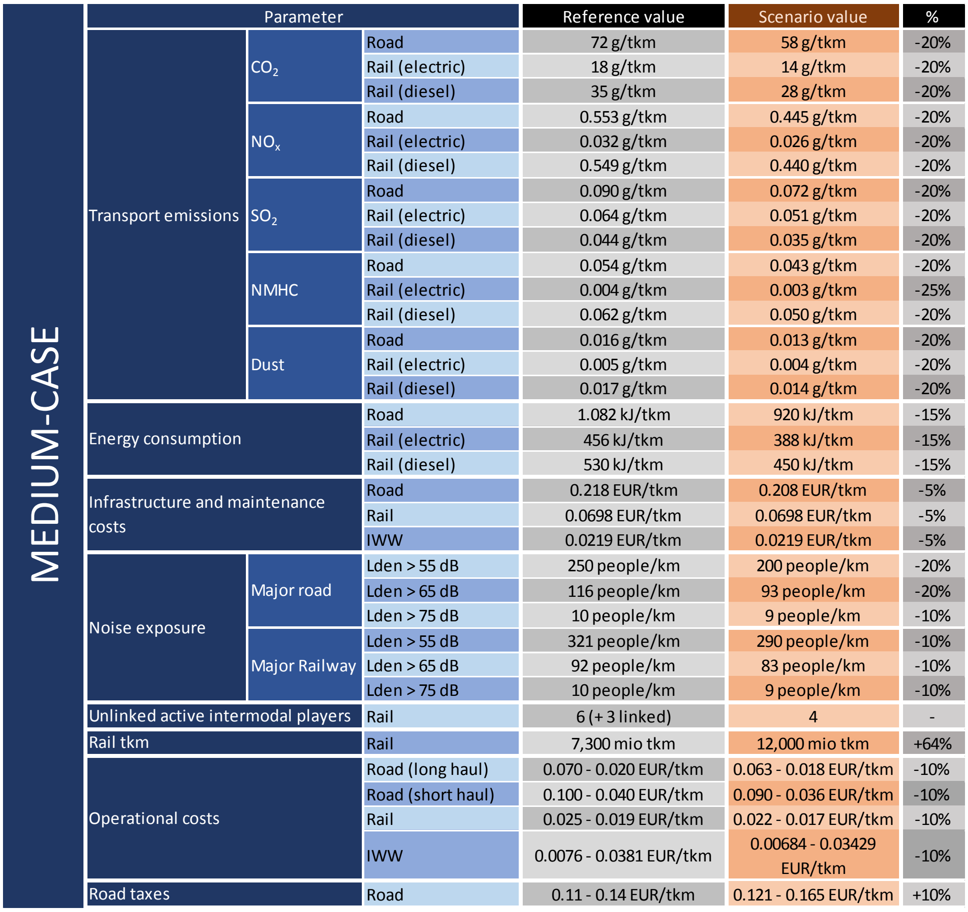
A.2. Worst case scenario



	Parameter			Reference value	Scenario value	%
WORST-CASE	Transport emissions	CO_2	Road	72 g/tkm	43 g/tkm	-40%
			Rail (electric)	18 g/tkm	16 g/tkm	-10%
			Rail (diesel)	35 g/tkm	32 g/tkm	-10%
		NO_x	Road	0.553 g/tkm	0.33 g/tkm	-40%
			Rail (electric)	0.032 g/tkm	0.029 g/tkm	-10%
			Rail (diesel)	0.549 g/tkm	0.495 g/tkm	-10%
		SO_2	Road	0.090 g/tkm	0.054 g/tkm	-40%
			Rail (electric)	0.064 g/tkm	0.058 g/tkm	-10%
			Rail (diesel)	0.044 g/tkm	0.040 g/tkm	-10%
		NMHC	Road	0.054 g/tkm	0.033 g/tkm	-40%
			Rail (electric)	0.004 g/tkm	0.004 g/tkm	0%
			Rail (diesel)	0.062 g/tkm	0.056 g/tkm	-10%
		Dust	Road	0.016 g/tkm	0.010 g/tkm	-40%
			Rail (electric)	0.005 g/tkm	0.004 g/tkm	-20%
			Rail (diesel)	0.017 g/tkm	0.015 g/tkm	-10%
	Energy consumption		Road	1.082 kJ/tkm	755 kJ/tkm	-30%
			Rail (electric)	456 kJ/tkm	410 kJ/tkm	-10%
			Rail (diesel)	530 kJ/tkm	475 kJ/tkm	-10%
	Infrastructure and maintenance costs		Road	0.218 EUR/tkm	0.240 EUR/tkm	+10%
			Rail	0.0698 EUR/tkm	0.0768 EUR/tkm	+10%
			IWW	0.0219 EUR/tkm	0.0241 EUR/tkm	+10%
	Noise exposure	Major road	Lden > 55 dB	250 people/km	150 people/km	-40%
			Lden > 65 dB	116 people/km	70 people/km	-40%
			Lden > 75 dB	10 people/km	6 people/km	-40%
		Major Railway	Lden > 55 dB	321 people/km	290 people/km	-10%
			Lden > 65 dB	92 people/km	83 people/km	-10%
			Lden > 75 dB	10 people/km	9 people/km	-10%
	Unlinked active intermodal players		Rail	6 (+ 3 linked)	2 (+ 2 linked)	-
	Rail tkm		Rail	7,300 mio tkm	8,000 mio tkm	+10%
	Operational costs		Road (long haul)	0.070 - 0.020 EUR/tkm	0.063 - 0.018 EUR/tkm	-10%
			Road (short haul)	0.100 - 0.040 EUR/tkm	0.090 - 0.036 EUR/tkm	-10%
			Rail	0.025 - 0.019 EUR/tkm	0.030 - 0.023 EUR/tkm	+20%
			IWW	0.0076 - 0.0381 EUR/tkm	0.00912 - 0.04572 EUR/tkm	+20%
	Road taxes		Road	0.11 - 0.14 EUR/tkm	0.11 - 0.14EUR/tkm	0%

Fig. 6. Worst case scenario (Troch et al., 2015)

A.3. Medium case scenario



	Parameter			Reference value	Scenario value	%
MEDIUM-CASE	Transport emissions	CO_2	Road	72 g/tkm	58 g/tkm	-20%
			Rail (electric)	18 g/tkm	14 g/tkm	-20%
			Rail (diesel)	35 g/tkm	28 g/tkm	-20%
		NO_x	Road	0.553 g/tkm	0.445 g/tkm	-20%
			Rail (electric)	0.032 g/tkm	0.026 g/tkm	-20%
			Rail (diesel)	0.549 g/tkm	0.440 g/tkm	-20%
		SO_2	Road	0.090 g/tkm	0.072 g/tkm	-20%
			Rail (electric)	0.064 g/tkm	0.051 g/tkm	-20%
			Rail (diesel)	0.044 g/tkm	0.035 g/tkm	-20%
		NMHC	Road	0.054 g/tkm	0.043 g/tkm	-20%
			Rail (electric)	0.004 g/tkm	0.003 g/tkm	-25%
			Rail (diesel)	0.062 g/tkm	0.050 g/tkm	-20%
		Dust	Road	0.016 g/tkm	0.013 g/tkm	-20%
			Rail (electric)	0.005 g/tkm	0.004 g/tkm	-20%
			Rail (diesel)	0.017 g/tkm	0.014 g/tkm	-20%
	Energy consumption		Road	1.082 kJ/tkm	920 kJ/tkm	-15%
			Rail (electric)	456 kJ/tkm	388 kJ/tkm	-15%
			Rail (diesel)	530 kJ/tkm	450 kJ/tkm	-15%
	Infrastructure and maintenance costs		Road	0.218 EUR/tkm	0.208 EUR/tkm	-5%
			Rail	0.0698 EUR/tkm	0.0698 EUR/tkm	-5%
			IWW	0.0219 EUR/tkm	0.0219 EUR/tkm	-5%
	Noise exposure	Major road	Lden > 55 dB	250 people/km	200 people/km	-20%
			Lden > 65 dB	116 people/km	93 people/km	-20%
			Lden > 75 dB	10 people/km	9 people/km	-10%
		Major Railway	Lden > 55 dB	321 people/km	290 people/km	-10%
			Lden > 65 dB	92 people/km	83 people/km	-10%
			Lden > 75 dB	10 people/km	9 people/km	-10%
	Unlinked active intermodal players		Rail	6 (+ 3 linked)	4	-
	Rail tkm		Rail	7,300 mio tkm	12,000 mio tkm	+64%
	Operational costs		Road (long haul)	0.070 - 0.020 EUR/tkm	0.063 - 0.018 EUR/tkm	-10%
			Road (short haul)	0.100 - 0.040 EUR/tkm	0.090 - 0.036 EUR/tkm	-10%
			Rail	0.025 - 0.019 EUR/tkm	0.022 - 0.017 EUR/tkm	-10%
			IWW	0.0076 - 0.0381 EUR/tkm	0.00684 - 0.03429 EUR/tkm	-10%
	Road taxes		Road	0.11 - 0.14 EUR/tkm	0.121 - 0.165 EUR/tkm	+10%

Fig. 7. Medium case scenario (Troch et al., 2015)

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