BRAINTRAINS

University of Antwerp

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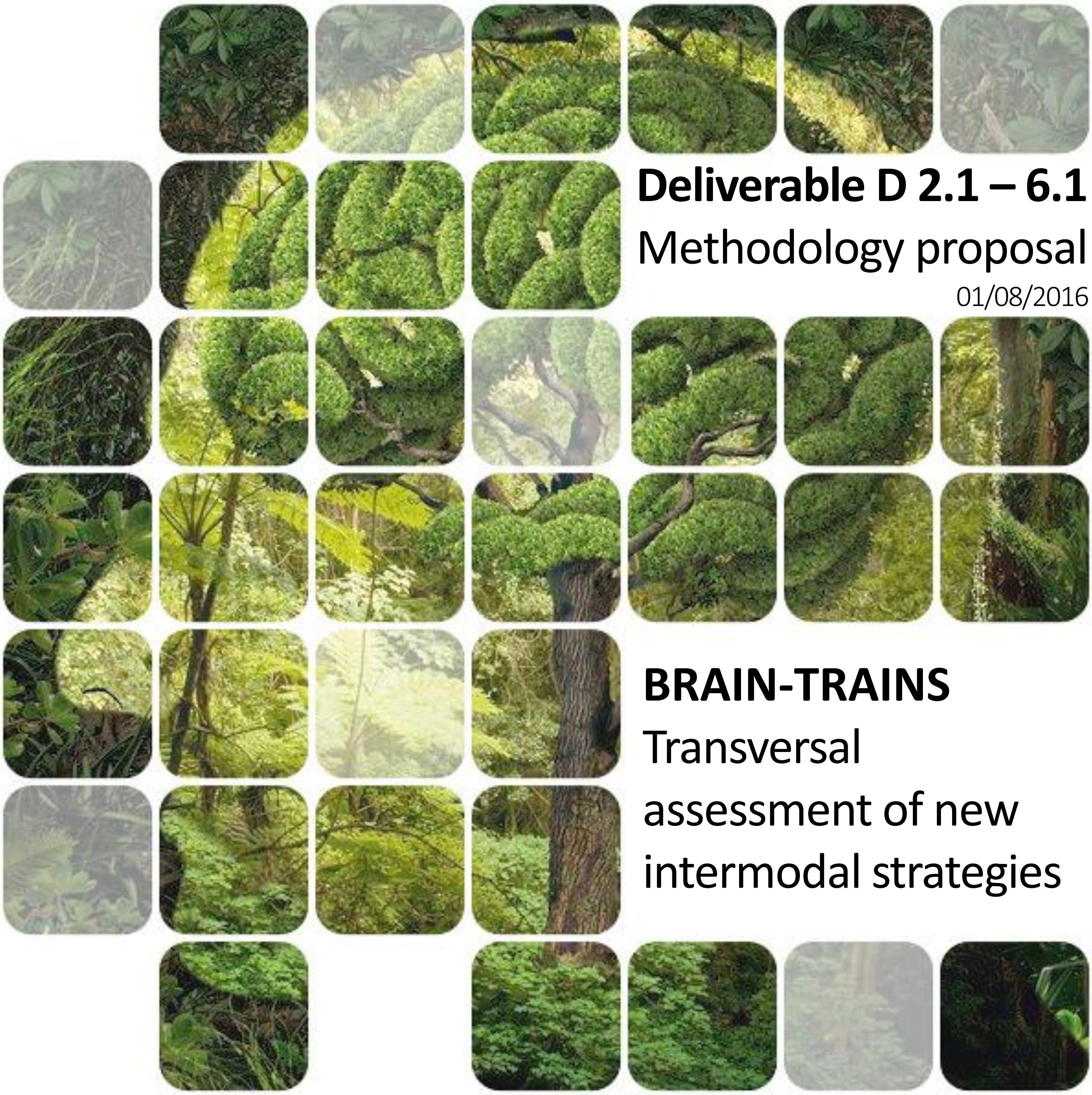
**BELGIAN RESEARCH ACTION THROUGH
INTERDISCIPLINARY NETWORKS**



Deliverable D 2.1 – 6.1
Methodology proposal
01/08/2016

BRAIN-TRAINS
Transversal assessment of new intermodal strategies

CONTENTS

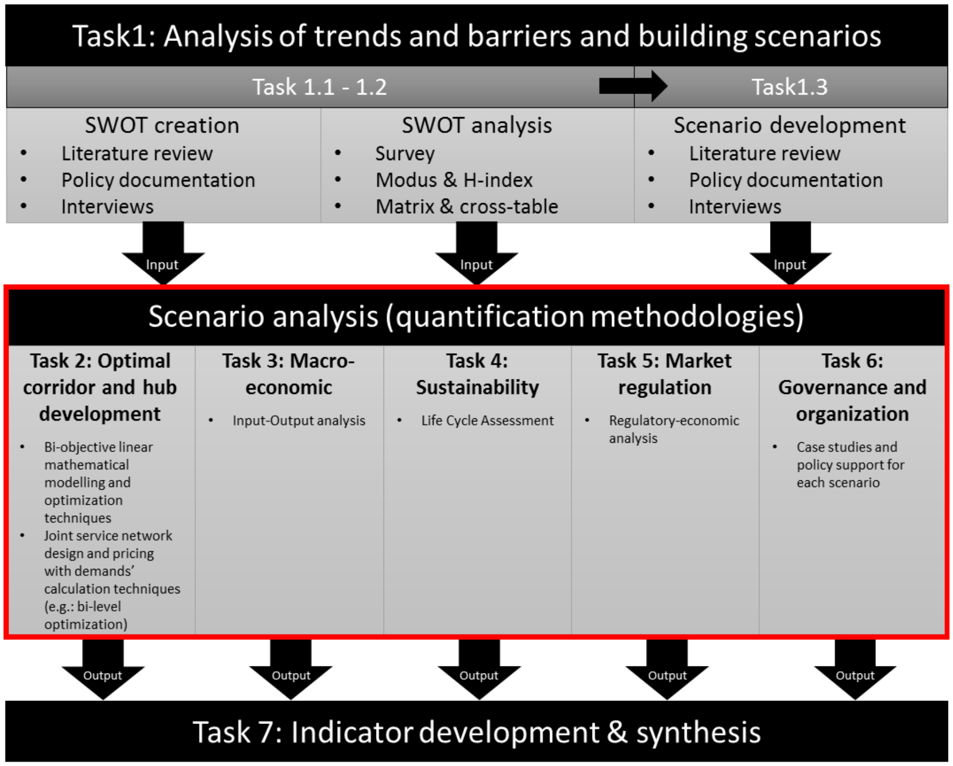
INTRODUCTION

The BRAIN-TRAINS project deals with the possible development of rail freight intermodality in Belgium. The main goal of the project is to develop a blue print establishing the detailed criteria and conditions for developing an innovative intermodal network in and through Belgium, as part of the Trans-European Transport Network and related to different market, society and policy-making challenges. The project develops an operational framework in which effective intermodal transport can be successfully established in Belgium, with attention to beneficial participation and commitment of all different stakeholders.

This analysis is built around five different main topics:

- (WP 2) The optimal corridor and hub-development.
- (WP 3) The macro-economic impact of intermodality.
- (WP 4) The sustainability impact of intermodality.
- (WP 5) Effective market regulation for a well-functioning intermodality.
- (WP 6) Effective governance and organization for a well-functioning intermodality.

FIGURE 1: STRUCTURE OF THE BRAIN-TRAINS PROJECT



SOURCE: OWN COMPOSITION

Figure 1 is showing the process mapping for this transversal BRAIN-TRAINS project. The current document is providing more information on the developed methodologies for work package 2 to 6, indicated by the red frame within this figure. From the first task of the project, where a SWOT analysis and a scenario development has been concluded, each partner started to focus on measuring the impact of the earlier found results in their specific field. As such all five mentioned fields have developed a new or adapted methodology that will allow these quantifications to be made. The result of this methodology development process will be presented within this combined deliverable (D 2.1 – D 6.1). In a later phase of the project, the methodologies will be used on the earlier developed scenarios in order to create a model for each field that will allow to quantify and measure the impact of possible future developments and decisions on rail freight transport development in Belgium. The outcome of these field studies will then be combined in task 7, in order to develop the corresponding indicators, and to perform a final synthesis.

TABLE 1: WORK PACKAGE CHARACTERISTICS

	Input	Output	**Rail in intermodal Transport**	**Rail Transport in general** (incl. intermodal transport)	**Belgium**	**Europe** (rail corridors)	**Single operator perspective**	**Multiple operator perspective** (open market)
Work Package 2 Optimal corridor and hub development	- emissions - taxes / subsidies - O-D matrix - operational cost (structure)	- modal split - cost/emissions - frequencies - price - revenu	+	+	+	+	+	-
Work Package 3 Macro-economic impact	- taxes and subsidies - VAT listings - supply and demand tables (turnover)	- added value - employment - multipliers - markov relations	-	+	+	-	-	+
Work Package 4 Environmental impact	- energy consumption - transport emissions - noise exposure	- life cycle assessment	-	+	+	-	-	+
Work Package 5 Regulatory impact	- operators info - rail demand	- optimal number of operators - regulation best practices	-	+	+	+	-	+
Work Package 6 Public administration and governance	- social network analysis - current level of integration	- desired level of interation	-	+	+	-	-	+

SOURCE: OWN COMPOSITION

For the development of the different methodologies for the five corresponding work packages or tasks, a set of inputs, outputs and work package context assumptions has been made. The result of this internal discussion is shown in table 1 and is used as a starting point for each field to develop their corresponding methodology. In addition, this information will also be used as a guidance for the interpretation of future results from each work package. This table will also be of crucial importance when the output of all models will be combined in the last phase of the project, as mentioned in the section above.

All work packages will focus on rail freight transport in general, which includes also intermodal transport with rail as the main mode of transport for inland transportation. Work package 2 (WP 2) will also focus more on the specific intermodal component of rail transport within intermodal transport, indicating the optimal corridor and hub development for this specific part of rail transport in Belgium.

The main geographical scope of the research is Belgium, as previously defined. However, work package 2 and 5 will also take into account the European context, and more specifically the possible impact of the European rail corridors of which three are operating on Belgian territory. Other work packages will also take into account the European context, as rail transport is often an international business, but these effects will not be quantified within the corresponding models.

A last characteristic is the market perspective. Work package 3 to 6 will take into account an open market perspective, whereas work package 2 will built its model around a single operator perspective, in order to simplify the modelling, optimization and calculating techniques as described in chapter 2.1.

Table 2: Links between work packages

Impact on	**Work Package 2** Optimal corridor and hub development	**Work Package 3** Macro-economic impact	**Work Package 4** Environmental impact	**Work Package 5** Regulatory impact	**Work Package 6** Public administration and governance
Work Package 2 Optimal corridor and hub development		++	++	++	+
Work Package 3 Macro-economic impact	+		-	+	+
Work Package 4 Environmental impact	++	-		-	-
Work Package 5 Regulatory impact	-	+	-		+
Work Package 6 Public administration and governance	-	+	-	+	

Source: Own composition

Table 3 above is showing the different links that exist between the five work packages. The table should be interpreted from left to right. As such, there is not necessarily an equal mutual relationship between two work packages, as one work package can influence another on a high level, where the latter does not have any influence on the first work package. As for the symbols, '-' is indicating that there is no or a weak correlation between the two work packages. '+' is representing a moderate to strong link and '++' is showing a very high influence on the work package.

Work package 2 has a very strong link with all other work packages, except for work package 6 where a moderate correlation is observed. Especially the calculated modal split (output of WP 2) and the corresponding transported volumes by each mode will impact the scenarios and as such the input parameters for the other work packages. In addition, the change in prices and revenues will impact the input-output model of WP 3, emissions will be a mutual factor with WP 4 an the developed model of WP2 will be a tool to calculate certain findings in WP 5.

Work package 3 is showing a moderate to strong impact on work packages 2, 5 and 6. Rail demand is a driving input factor for the input-output analysis in WP 3 and is therefore a common parameter with these work packages. In addition the studied Markov-chain relations between the different actors in WP 3 can be linked to the social network analysis performed in WP 6. There is only a limited direct correlation between the macro-economic impact (WP 3) and the environmental impact (WP 4)

The above mentioned factors also indicate a moderate to strong influence of work package 4 on work package 2, whereas work package 5 is influencing work package 3 and 6, and work package 6 is impacting on work package 3 and 5.

In the next chapters, the developed methodology for each work package will be described for each corresponding field.

DELIVERABLE 2.1: Methodology proposal for optimal corridor and hub development

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Work package (WP) 2 aims at providing tools from the operations research domain, in order to highlight how effective intermodal rail transport is in Belgium. The objective of this package is also to give more insight on the decision-making process of the different stakeholders in the intermodal chain. The methods are based on the area of expertise of optimization, which aims at translating a managerial problem into a mathematical model that should be optimized. The main components of the methodology consist in:

1) Identifying the managerial problem.
2) Modelling the problem using mathematical programming.
3) Computing the solutions.
4) Translating the scenarios.

In this WP, two models are proposed to provide decision-making insights to the Belgian stakeholders of rail and intermodal rail transport. The first model stays at a strategic level and focuses on the network design of road and intermodal freight transport. The second model is at a tactical level and focuses on the service network design and pricing problems of intermodal rail transport.

The two models considered are developed in the following parts of the document.

1. IDENTIFYING THE MANAGERIAL PROBLEM

With the rising interest to stimulate intermodal transport, various topics provided interesting areas of research and investigation to the field of Operations Research. The first developed multi-modal network models that were able to handle intermodal flows appeared in the early 1990s (Caris et al., 2013). The most notable considered decision problems are intermodal freight location-allocation optimization problems, internalizing external costs, consolidation strategies and service network design.

1.1 Model 1

The managerial problem identified in this section is the location/allocation problem of intermodal terminals. When dealing with intermodal transport, some intermodal terminals are required on the route, in order to proceed to the transhipment of goods from one mode of transport to the other. Correctly locating intermodal terminals is of strategic importance in terms of intermodal competitiveness in relation to road (Mostert and Limbourg, 2016). Indeed, the main benefits of intermodal transport are generally obtained during the long-haul travel by the environment friendly mode of transport. However, if a terminal is wrongly located, it might increase the pre- and post-haulage distances by truck between the origin node and the first intermodal terminal, or between the second terminal and the destination node. If these drayage distances are too long, it can happen that the long-haul travel by the environment friendly mode cannot compensate anymore for the disadvantages of the pre- and post-haulage travels by truck.

The model also tackles the allocation of flows between the different possible modes of transport. It allows determining the impact of specific policies on the flow repartition between intermodal and road transport. It can also show the flow transfers inside the intermodal market share, between rail and inland waterway (IWW), depending on the implemented initiatives.

1.2 Model 2

A particular aspect that closely affects intermodal transport competitiveness, and that is yet under-studied in the corresponding literature, is the determination of the right service tariffs, known as the *pricing strategy* (Bontekoning et al., 2004). Generally speaking, pricing strategies are distinguishable in the way they handle the interplay between profitability and competitiveness. A service price has to be high enough to cover the costs, and hence generate a profit, and low enough to remain attractive to the target customers. Bontekoning et al. (2004) identify two levels, at which the pricing strategy operates. The first level is that of the individual actor in the intermodal chain. Previous studies at this level were mainly concerned with calculating opportunity costs and providing educated pricing guidelines, mostly from the perspective of the network (main haul) and the drayage operators. The second level is that of the entire door-to-door chain. Service pricing decisions at this level are taken from the perspective of the service providers (carriers), while accounting for the potential competition and the target customers' (shippers') choices. As pointed out by the literature review in Tawfik and Limbourg (2015), there is a peculiar gap in the literature of solid optimization approaches tackling intermodal pricing problems that belong to the latter category. Nevertheless, their relative importance and relevance to the competitiveness of intermodal transport is acknowledged through the previously conducted SWOT analysis within the BRAIN-TRAINS project (Deliverable D1.1, D1.2).

We consider an approach that explicitly addresses intermodal service prices as decision variables within a numerical optimization problem. In particular, we highlight the non-trivial trade-off between the generated revenues through the collected tariffs and the cost expenses through the operated services; a service performance can be increased, and thus more customers attracted, at the expense of additional operating costs, and vice versa. The problem is tackled from the economic perspective of a single intermodal service provider, belonging to the tactical planning horizon and in the interest of profit maximization. Two main categories of joint decisions are examined: the service prices as received by the target clients and the service design reflected in their corresponding operating frequencies during a medium-term interval, typically one week.

2. MODELLING THE PROBLEM USING MATHEMATICAL PROGRAMMING

The second step of the methodology is to develop the mathematical formulation of the managerial problem. A mathematical optimization problem is composed of four main elements: parameters, variables, objective function and constraints. The input of the model consists of the different parameters, which take a fixed value. The output of the model consists in the variables, which are identified at the end of the optimization process. The model is structured according to two main parts: the objective function, that should be minimized or maximized, and the different related constraints applicable to the problem under consideration. The generic structure of a general mathematical model is given by:

Minimize/Maximize

- Objective function

Subject to:

- Constraint 1,
- Constraint 2,
- …
- Constraint n.

2.1 Model 1

The model developed in this section of WP2 allows optimizing two main kinds of objectives. The first one relates to economic aspects: trying to obtain the minimum total operational transportation costs on the road and intermodal networks. The second objective that can be optimized relates more to environmental concerns. This version of the modelling can indeed find the solution that minimizes the total amount of specific emitted air pollutants or external costs.

The main input parameters of the formulation are the distances (in km) between two nodes (each node representing a NUTS3 region) using a specific mode of transport (road, rail or IWW), the cargo-aggregated demand for one year between the nodes of the origin/destination matrix (in t), the costs/emissions/external costs values (in € or t of pollutants) for the transportation and transhipment of goods between modes, as well as the potential subsidies/taxes (in €/tkm) allocated to certain modes by public authorities. The output values consist of the location where to build additional terminals, the type of terminal to locate (rail or IWW), and the flow repartition (in tkm) between road, intermodal with rail, and intermodal with IWW transport.

The model is structured according to the following objective functions and constraints:

Minimize either of the following:

- Global operational costs.
- Air pollutant emissions.
- External costs.

Subject to:

- A maximum of p terminals can be located.
- Existing terminals should be open.
- Demand should be satisfied.
- Flows should leave their origin.
- Flows cannot go through a closed terminal.
- Flows should be conserved between the intermodal terminals.
- Flows should be non-negative.

One characteristic of the model is that it can be used for solving one specific objective or for considering two potentially contradictory objectives at the same time (for instance, an economic versus an environmental objective). Under this configuration, a bi-objective model is thus solved, which leads to the generation of a set of Pareto-optimal pairs of solutions. The latter are solutions of the model, for which none of the objective functions can be improved, without worsening the value of the other one. Indeed, economic and environmental objectives may lead to different optimal solutions. Pareto equilibrium for these objectives is found when the optimal combination of economic-environmental objectives is reached, i.e. when it is not possible to reduce the obtained optimal value of costs, without increasing the value of the emitted pollutants/external costs. Different combinations of Pareto-optimal pairs can be found, depending on the level of economic or environmental optimality that should be achieved. The junction of all these combinations of economic-environmental objectives on a two-dimensional graph is called the Pareto frontier. The latter thus allows the decision-maker to make the choice inside a set of potentially optimal solutions, some focusing more on one objective, and others focusing more on the second one.

2.2 Model 2

A key issue in modelling the above proposed problem is how to represent the target shippers' reasoning, and consequently, the demand volumes of the intermodal services in question. We notice an innate hierarchy in the problem's definition due to the chronological order in the decision-making: first, the intermodal operator chooses his service pricing and design strategy, while, afterwards, the target shippers optimally react to those decisions by choosing (or not) the offered services.

In that sense, a certain optimization framework was proven adequate for similar hierarchical and non-cooperative decision schemes, yet largely overlooked in intermodal transport planning problems, namely: bilevel programming.

The concept is principally adapted from game theory, with the name of "Stackelberg games". It depicts a game that involves two sequential layers of players: a leader and one or more follower(s). By definition, the leader has the privilege of making the first move in the game, while being able to anticipate the optimal reaction of the follower(s) to his chosen strategy. The solution (or the chosen strategy) is decided upon by working it backwards; the game is thus played from the point of view of the leader. Stackelberg games were first introduced into mathematical programming under the self-explanatory name of "mathematical programs with optimization problems in the constraints", and became later known as "bilevel programs".

The joint intermodal service pricing and design problem is constructed following a bilevel structure as follows:

	Upper level (leader)	**Lower level (followers)**
Decision maker:	Intermodal operator/service provider.	Shipper firms.
Decisions:	Services' prices. Services' frequencies.	Flows on leader's (intermodal) itineraries. Flows on competition (= all-road itinerary).
Objective:	Profit maximization.	Logistics costs minimization.

An assumption that should remain unchanged throughout the model development is the ability for the competition, represented by trucking services, to accommodate all the demands of every shipper firm. It is thus ensured that the leader/intermodal operator is prevented from setting infinite tariff schedules on his services. It is equally important to assume that the competition shows no price or service quality change throughout the process.

Our formulation takes the initial form of a static path-based multi-commodity formulation, as introduced by Crainic (2000), while our bilevel model follows the main joint pricing and design structure as presented by Brotcorne et al. (2008).

2.3 Freight choice modelling

The general behavioural assumption is that shippers seek to minimize their total logistics costs, and thus increase their respective utility. In this context, utility is used in the sense of the received benefits or advantages from a purchased service according its corresponding value. To clarify, in standard passenger traffic, an individual decides on a certain mode of transportation (e.g.: car, public transportation, etc.) with respect to the realized benefits of this mode (i.e.: a weighted combination of the out-of-pocket expenses, transit time, safety, punctuality, etc.). Similarly, in freight transport, a mode/service choice is based on the realized utility. There is a sufficiently wide literature that considers a corresponding functional representation that goes beyond a trivial weighted sum of service attributes. Several individual items interact in complex ways in order to determine the total logistics costs, involving commodities', shippers' and shipments' characteristics, in relation to level-of-service and mode attributes. An attempt to minimize a single cost element may result in an increase in the total costs.

We refer to Vieira (1992) for a generally acknowledged skeleton of logistics cost components:

- **Transportation costs:** freight chargers during transportation.
- **Mode-specific constants and variables:** order and handling costs.
- **Value of in-transit stocks:** in-transit and inventory capital carrying costs.
- **Discount rate-related variables:** loss, damage and unavailability of equipment costs.
- **Intangible service-related attributes:** satisfaction with contract terms, perception of the effort to deal with the carrier and availability of Electronic Data Interchange (EDI) services.

Nevertheless, an application of a normative approach provided by cost models repetitively fails to coincide with the shippers' actual choices. This is chiefly due to two reasons: the non-uniformity of the service perception among the shippers; and the lack of certain significant information for the cost calculation (e.g.: discount rate, cost per order and the number of days to collect a loss and damage claim).

The solution, as proposed by Ben-Akiva et al. (2013), is to combine discrete choice methods with the minimization of total logistics costs, in the same way that utility maximization is modelled for individuals' choice behaviour in passenger traffic. The shippers' modal selection can be specified in quantitative terms by employing a random utility model, where the choice model estimation is in fact an estimation of the missing cost variables information, together with the importance of the different cost components.

Random utility models generally state that decision makers (shippers in our case) have a certain objective (utility) function and choose the alternative with the highest utility. Since outside observers cannot measure decision makers' utility functions exactly, the utilities are treated by the analysts as random variables. What can be observed instead are the choices which depend on those utilities. Therefore, the event of choosing a certain alternative is considered stochastic with choice probability depending on the distributional assumption of the disturbance term in the utility function.

For the freight choice case, the utility of a certain mode i for shipper n is expressed as follows (Ben-Akiva et al., 2013):

$$U_{in} = \mu\left(logistics\ costs_{in}\right) + \varepsilon_{in}$$

Where:

- μ: Negative scale parameter.
- ε_{in}: Unobservable or random component.

The pool of data to be considered is based on a revealed preference (RP) approach that analyses actual choices in relation to the actual situation. In this exercise, prospective client firms of container transport are to be interviewed in a survey about time-average statistics for some of their specific origin-destination pairs, in order to reflect the effect of network characteristics uniquely. In particular, the following information is to be elicited through the survey:

- **Generic variables:** size of the firm, annual sales, annual tonnage, availability of own fleet of vehicles, maximum acceptable delay, environment awareness and emissions' penalization.
- **Mode-specific variables:** corridor information, share among corridor shipments, shipment size, price of product shipped, freight rate, order unit cost, transit time, fraction of shipments arriving when wanted, fraction of shipments lost or damaged, fraction of time equipment being available, effort to deal with carrier and EDI availability.

To the extent of our knowledge, integrating a discrete choice methodology in the reaction of the followers within a bilevel pricing and design model is an innovative approach.

3. COMPUTING THE SOLUTIONS

Once the model formulation is developed, it should be translated into a programming language in order to be solved by a computer. The chosen programing language is Java and the model is solved through the use of a commercial solver developed by IBM: ILOG CPLEX 12.6. The formulation is solved on a personal portable computer (Windows 7, Dual-Core 2.5 GHz, 8 GB of RAM).

CPLEX, as a solver for such mathematical programs involving both discrete and continuous variables, applies state-of-the-art searching algorithms based on the idea of iteratively solving a sequence of the problem's relaxation in order to provide bounds on the solution, known as: Branch-and-Bound. In the same context, a set of techniques are implemented at different stages to reach a tighter formulation and land an optimal solution more efficiently.

As for estimating the freight choice model within the second formulation, the open source freeware Biogeme will be used. Biogeme is designed for the maximum likelihood estimation of parametric models in general, with a special emphasis on a long list of predetermined discrete choice models such as the logit and probit models, as well as their variances.

4. TRANSLATING THE SCENARIOS

Once the optimal solution (single objective model) or the optimal pairs of solutions (bi-objective model) is generated, the last step of the methodology is to vary the different input parameters in order to assess the robustness of the modelling and also to evaluate the impact of different policies on the results.

Nevertheless, a set of basic assumptions will remain constant in all scenarios. In particular, within the service pricing and design model, we consider a fixed underlying physical network that comprises three modes of transportation: road, rail and inland waterways; as well as a set of terminals where the freight transhipment from one mode to another takes place. A service, in our notion, is defined by its origin, destination, transport mode and departure day of the week, while an intermodal itinerary is formed by at most three service legs. The network is assumed to be fully connected in terms of all-road/trucking services, making it feasible to accommodate the whole set of shippers' demands.

Among the scenario parameters, we distinctly consider the following inputs:

- Infrastructure and maintenance costs of the operating services, in terms of a fixed and variable component.
- Road taxes, e.g.: Viapass.
- Subsidies.
- Origin-destination matrix of flows over the network.
- Emission levels/external costs of pollutants.

The models compute in return the following outputs:

- Modal split, in terms of tkm.
- Suggested intermodal service prices.
- Intermodal carrier's profit.
- Terminal locations.

Both models give the possibility to determine the impact of several initiatives on the listed outputs. The different scenarios developed in the deliverable 1.3 of the BRAIN-TRAINS project are implemented within this last part of the methodology. Indeed, in previous deliverables, the project proposed different important parameters to consider when dealing with intermodal and rail transport in Belgium. These parameters were retrieved out of a SWOT analysis, and selected for their relevance by a panel of experts, using the so-called Delphi method. Different values are assigned to each parameter, according to the scenario that is used (best-case, worst-case, middle-case). Our model will be tested according to these different scenario values and the results in terms of modal split (tkm), terminal location and type will be determined.

One objective of the BRAIN-TRAINS project is to provide interesting knowledge on rail and intermodal transport in Belgium in different areas of expertise. The most interesting issue in this framework is how the different work packages of this project can be linked together. The macro-economic, environmental, regulatory and public administration and governance domains all have strong links with the operational optimal corridor and hub development. To illustrate this connection, we develop here how the input/output of this model of WP2 are connected with the input/output of other WPs. The main common indicators between the model and the other WPs are the modal split and the calculated volumes in tkm. Indeed, this output of our model can be used as an input of the model of the macro-economic impact package, in their input/output methodology. The amount of tkm on the Belgian network also serves as the basis of the computation of the global emissions for the environmental impact work package. The other way around, the amount of emissions per tkm calculated by WP4 can help in optimizing networks in terms of environmental impact. The calculated modal split and flow repartition will also influence the computation of the different scenarios for the regulatory issues of WP5. Finally, WP6 can also use modal split results in order to elaborate on the relationships linking the different actors of public administration, in the framework of intermodal and rail transport.

A further refinement of the computed outputs will be performed as part of the scenario calculations in next deliverables, provided the close links between the different WPs and the imaginable cyclic relationships, for the sake of verifying the modifications and validating the interactions between the WPs.

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DELIVERABLE 3.1: Methodology proposal for the macro-economic influence of rail freight transport

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Work package (WP) 3 aims at providing tools from the macro-economic research domain, in order to measure the impact of rail transport on the Belgian economy. This research includes rail transport as a part of the intermodal chain. The SWOT analysis in deliverable 1.1 – 1.2 has shown that both economic growth and transport growth share a strong connection, impacting on one another (Hilferink, 2003). Although transport demand is a derived demand, and therefore usually following the economic growth and industrial production, changes within the transport sector and decisions impacting on transport in general do have an impact on the economic growth of a country as well (Konings et al., 2008; UNCTAD, 2014). As such it is important to understand and measure the relationship between rail transport and the national economy or macro-economic level.

Within this deliverable, the main components of the proposed methodology will be explained. An overview will be given according to four sequential steps:

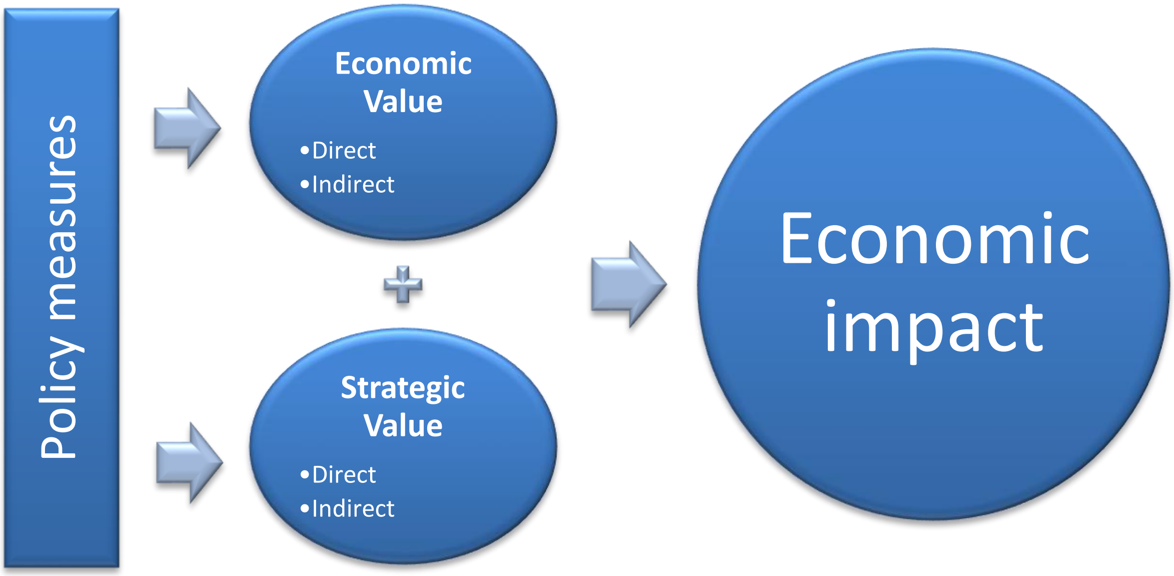
1. Problem identification: why measuring the macro-economic impact?
2. Methodology: input-output, multipliers and linkages
3. Risk analysis: data collection and validity of the results
4. Link with the scenarios: translation of tkm and a sensitivity analysis

In this WP, the analysis will be built in three steps. First the framework of an input-output model is applied to the sector of rail operations and the multipliers for the national economy are calculated. In a second step, the connections between the different sectors of the national economy and the actors involved in rail transport are investigated through linkages between the rail freight sector and other industries of the national economy. Both steps are explained in section 2. Section 3 highlights possible problems and risks for the analysis of the current state. This current state will then be further analysed in a third step, by linking the scenarios from WP 1 to the obtained results. This will be discussed in section 4.

1. PROBLEM IDENTIFICATION: WHY MEASURING THE MACRO-ECONOMIC IMPACT?

The SWOT analysis in WP 1 has shown the importance of high productivity, flexibility and a customer-oriented approach for rail transport and other related sectors, in order to obtain a competitive advantage and increase its attractiveness. Decisions and actions taken in the field of rail freight transport which aim at achieving these aspects also impact to a greater or lesser extent on the rest of the economy. As shown in figure 1, in order to quantify these effects, direct and indirect effects on the economic value should be taken into account, as well as direct and indirect effects on the strategic value (Kuipers et al., 2005; Coppens et al., 2005).

FIGURE 1 – ECONOMIC IMPACT OF MEASURES DIRECTED TO FREIGHT TRANSPORT



SOURCE: OWN COMPOSITION BASED ON KUIPERS ET AL. (2005) AND COPPENS ET AL. (2005)

Economic value is expressed by the physical and monetary effects of policy measures. Direct effects of transport decisions and investments are often calculated by a classical cost-benefit analysis approach. However, Mouter et al. (2012) and Beukers et al. (2012) indicate the weakness of such approach due to the absence or underestimation of the indirect economic effects. In addition to the social costs and benefits, also indirect effects should be taken into account, which exist because the economic sectors are interrelated due to which changes in demand and supply in one sector ignite a ripple effect throughout the rest of the economy (Coppens et al. 2005).

Strategic value is often for many businesses and sectors a reason to remain active in a particular region or country. However, this effect is not always calculated in the direct and indirect economic value of transport. As such, it is important to also quantify the direct and indirect effects of the strategic significance of freight transport to the rest of the economy (Kuipers et al., 2005).

The goal of this WP is to develop a methodology to quantify both the economic and strategic value of rail freight transport. Coppens et al. (2007) performed a similar research for the economic impact of port activity, by applying a disaggregate analysis for the case of Antwerp. Within their study, the input-output technology is used to identify the multipliers capturing all direct and indirect economic effects, measured by the change of two macro-economic parameters: employment and added value. This information is then used to define the strategic value. This is done by using the Markov-chain to identify the relationships or linkages between port actors and the rest of the economy, and how these relationships can change under the influence of certain policy measures impacting the port and its environment.

In the next section, the input-output methodology will be explained, as well as the use of corresponding multipliers and the Markov-chain theory to identify strategic linkages. This will be done in the next section by means of a simplified example and the results obtained from the study of the port sector.

2. METHODOLOGY: INPUT-OUTPUT, MULTIPLIERS AND LINKAGES

In order to capture the chain effect discussed in the previous section, the methodology of an input-output table is often used in similar studies. With this methodology, both the direct and indirect impact of modifications in the rail freight transport sector are captured by estimating the total effect on the national economy. However, whereas the port study by Coppens et al. (2007) used a regional input-output table, the study of economic impact of rail freight transport on the national economy requires using national input-output tables. The Federal Planning Office (2015) is publishing these national input-output tables every five years. The last version takes into account the input-output tables of 2010 and was published in December 2015.

2.1 General framework

The methodology of input-output analysis has been developed by the Russian economist Wissily Leontief (Miller & Blair, 2009). Table 1 gives a general overview of the structure of a national input-output table.

TABLE 1 – STRUCTURE OF A NATIONAL INPUT-OUTPUT TABLE

	1	**2**	**…**	**N**	**X**	**F**	**C**
1	c_{11}	c_{12}	…	c_{1n}	x_1	f_1	c_1
2	c_{21}	c_{22}	…	c_{2n}	x_2	f_2	c_2
…	…	…		…	…	…	…
N	c_{n1}	c_{n2}	…	c_{nn}	x_n	f_n	c_n
M	m_1	m_2	…	m_n		m_f	
VA	va_1	va_2	…	va_n			
C	c_1	c_2	…	c_n			

N = Number of industries in the economy
C_{ij} = Output of industry i delivered to industry j
C_n = total input / output of industry n
VA = Value added
M_j = Import
X_i = Export
F_i = Final demand

SOURCE: OWN COMPOSITION BASED ON COPPENS (2006) AND COPPENS ET AL. (2007)

In a national input-output model, the economy is split into n industries. According to the NACE classifications, active companies are divided amongst these n industries (Coppens, 2007). The output of an industry i can be delivered to a certain industry j, indicated by parameter C_{ij}. Other possibilities are that the output of an industry i is exported, indicated by parameter X_i, or is used by exogenous actors such as final consumption by families or investments by the government. This is the final demand, indicated by parameter $F_{i.}$ As such, the total output of an industry i, indicated by parameter $C_{i,}$ can be calculated according to formula (1):

$$c_i = \sum_{j=1}^{n} c_{ij} + x_i + f_i \tag{1}$$

The same logic can be applied to obtain the purchases or input of each industry j (Coppens, 2006). The input of each industry i to industry j is added to the input or import bought from outside of the national economy, indicated by parameter M_j. As the total input of a certain industry should be the same as the output of that industry ($c_i = c_j$), the difference can be calculated as the added value that this industry is generating (Miller & Blair, 2009). This is shown in formula (2) and (3):

$$VA_j = c_j - \sum_{i=1}^{n} c_{ij} - m_i \tag{2}$$

$$c_j = \sum_{i=1}^{n} c_{ij} + m_i + VA_j \tag{3}$$

2.2 Simplified example

How such an input-output table is calculated will be explained by using a simplified example based on Van Gastel (2015) and an illustration of input-output calculations by Miller and Blair (2009).

A first step is to collect the supply and demand tables from the national accounts. These tables are published every year by the National Bank of Belgium (NBB, 2015) and used every five years by the Federal Planning Office to calculate the national input-output table (Federal Planning Office, 2015). The supply and demand tables show the transactions between companies, indicating the structure of production costs, revenues generated from the production process, and transactions coming from import and export (NBB, 2015). The main difference between supply –and demand tables and an input-output table, is that the former identifies the relationship between products and industries, where the latter gives more insight in the mutual relationship between industries (Van Gastel, 2015).

Table 2 shows a simplified example of a possible supply table. Within this table, the output of each industry can be analysed.

For example, the chemicals industry is providing 100 units of PVC and 50 units of plastic. Cars are manufactured by the car manufacturing industry (200 units) and they are partially bought as an input from outside of the national economy (40). In this respect, import can be seen as an industry which is delivering an output of 40 units to the national economy.

TABLE 2 – SIMPLIFIED SUPPLY TABLE

	Chemicals	Plastic	Machines	Car man.	Energy prod.	Import
PVC	100	0	0	0	0	0
Plastic	50	200	0	0	0	0
Machines	0	0	410	0	0	0
Energy	0	0	0	0	815	0
Cars	0	0	0	200	0	40
TOTAL	**150**	**200**	**410**	**200**	**815**	**40**

SOURCE: OWN COMPOSITION BASED ON VAN GASTEL (2015)

Table 3 shows a simplified example of a possible demand table. Within this table, the input of each industry can be analysed.

For example, the chemicals industry is using 5 units of PVC, 50 units of machines and 30 unit of energy. Cars are used by the car manufacturing industry (20 units) and they are partially sold to buyers outside of the national economy (190). In this respect, export can be seen as an industry which is buying an input of 190 units from the national economy. Cars are also used outside of the defined industries and export, resulting in a final demand by families and the government of 30 units.

TABLE 3 – SIMPLIFIED DEMAND TABLE

	Chemicals	Plastic	Machines	Car man.	Energy prod.	Export	Final demand
PVC	5	20	0	0	0	75	0
Plastic	0	25	0	10	0	115	100
Machines	50	15	10	35	100	150	50
Energy	30	5	15	25	100	540	100
Cars	0	0	0	20	0	190	30
TOTAL	**85**	**65**	**25**	**90**	**200**	**1070**	**280**
Added Value	*65*	*135*	*385*	*110*	*615*		
TOTAL	**150**	**200**	**410**	**200**	**815**	**1070**	**280**

SOURCE: OWN COMPOSITION BASED ON VAN GASTEL (2015)

It should be noticed that the sum of each corresponding row in table 2 and 3 would equal the same amount. This can be explained by the earlier statement that, on the condition that import, export, final demand and added value are included in the calculation, the total input of an industry should be the same as the total output of that industry (Miller & Blair, 2009). As such, the total amount of products used or exported should also equal the total amount produced or imported from this product.

For example, 240 cars are produced as an output (200 by the car manufacturing industry within the national economy and 40 are imported), while 240 cars are also used as an input (20 going to the car manufacturing industry, 190 are requested from outside the national economy and 30 are used by families and the government).

As a consequence, the added value for each industry can also be calculated. This is obtained by calculating the difference between what is needed for the total production of an industry and what is supplied as an output by this industry in return of these inputs. The added value for each industry is shown in table 3.

For example, the chemicals industry is producing and supplying 150 units (100 PVC + 50 plastic). In order to be able to produce these units, a total of 85 units is required by this industry (5 PVC + 50 machines + 30 energy). As such, the added value of the chemicals industry can be calculated as 65 (150 outputs – 85 inputs).

In a second step, the data of the demand table has to be corrected. The reason for this is that the obtained supply table is created based on the basic prices, or the actual product value based on the cost of production, where the demand table is calculated based on the commercial or market prices, including taxes, subsidies, transport margins and handling margins (Van Gastel, 2015). Indeed, companies can adapt the price of a product they are selling according to national laws, subsidies and their obtained profit margin (Coppens, 2006). Therefore, the price paid by an industry demanding a certain product is different from the actual product value. Within this example, it will be assumed that the demand table in table 3 is already adapted based on the remarks made in the previous paragraph.

In a third step, the actual merge of both tables can be executed. Thereby, the input-output table with a sector-sector comparison is obtained by calculating the ratio for each industry:

$$Input - Output\ coefficient\ between\ sector\ A\ and\ B = \sum_{i=1}^{n}\left(Output\ of\ product\ i\ by\ sector\ A * \frac{Input\ of\ product\ i\ by\ sector\ B}{Total\ input/output\ product\ i}\right) \qquad (4)$$

As such, the input – output relation between two sectors can be calculated by multiplying the output of each product of the first sector with the relative use of the concerned product by the second sector, and finally summarising the results for all products.

For example:

Industry A = Chemicals industry
Industry B = Plastic industry

*- For the product “PVC”: Output “PVC” by chemicals * (input “PVC” by plastic / Total I-O of “PVC”).*
*- For the product “Plastic”: Output “Plastic” by chemicals * (input “Plastic” by plastic / Total I/O of “PVC”).*
- No other output is produced by the industry of chemicals.

Input-output relation between sector A and B =

*100 * (20 / 100) + 50 * (25 / 250) + 0 * (15 / 410) + 0 * (5 / 815) + 0 * (0 / 240) =*

20 + 5 + 0 + 0 + 0 = 25

TABLE 4 – INPUT-OUTPUT TABLE

	Chemicals	Plastic	Machines	Car man.	Energy prod.	Export	Final demand	**TOTAL**
Chemicals	5	25	0	2	0	98	20	**150**
Plastic	0	20	0	8	0	92	80	**200**
Machines	50	15	10	35	100	150	50	**410**
Car. Man.	0	0	0	17	0	158	25	**200**
Energy prod.	30	5	15	25	100	540	100	**815**
Import	0	0	0	3	0	32	5	**40**
TOTAL	**85**	**65**	**25**	**90**	**200**	**1070**	**280**	
Added Value	*65*	*135*	*385*	*110*	*615*			
TOTAL	**150**	**200**	**410**	**200**	**815**	**1070**	**280**	

SOURCE: OWN COMPOSITION BASED ON VAN GASTEL (2015)

When the input-output coefficient between sectors is calculated using equation 4 for each possible relation between two industries, the input-output table is obtained as shown in table 4. The red circle shows the result of the example previously explained. It should be noted that the inversed relationship, between the plastic industry and the chemicals industry, results to 0. This can be explained by the information that the plastic industry only has 200 outputs of plastic, while the chemicals industry is not using any plastic as input. As such, the only relation between the plastics industry and the chemicals industry, is in the direction of chemicals providing inputs towards the plastic industry.

This also explains how the input-output table in table 4 can be read and interpreted. Reading it from left to right, the output relation between the row industry and the column industry can be analysed. The chemicals industry is indeed providing an output of 25 towards the plastic industry, whereas the plastic industry is not providing any output to the chemicals industry. Reading the table from top to bottom, the input relation is showing itself, by indicating what each column industry is using from a row industry. From the example, it is indeed clear that the plastic industry is using 25 inputs from the chemicals industry, whereas the chemicals industry is not using any input from the plastic industry.

2.3 Multipliers

An input-output table can be used to calculate technical coefficients for the national economy (Coppens, 2006; Miller & Blair, 2009). Then, these coefficients can be used to obtain multipliers that measure the impact of a change in input or output for one of the industries on the rest of the economy.

The **Leontief multiplier** measures the total effect on the output of the national economy by a change in final demand for one of the industries. It is expected that a change of one unit in final demand in industry i results in a total output change greater than the initial change of one unit. This is explained by the chain effect each change in final demand is invoking. In our example above, an increase in final demand from the plastic sector would not only result in a direct output increase for this sector. Instead, the plastic sector would require additional inputs from the sectors it is related to, in our example identified as the plastics industry, the chemicals industry, the machines industry and the energy industry. As such, the output from these industries would also increase, and in their turn these sectors would require additional inputs from the sectors they are related to. As such, a ripple effect would impact the total output of the national economy.

In order to calculate the Leontief multiplier for a sector, the technical input coefficients for the relationship between each industry needs to be obtained. This corresponds with the intermediate usage of products between industries. The following formulas can be used:

$$A = C * c^{-1} \tag{5}$$

Where C is a matrix with all intermediate deliveries c_{ij}, as shown in table 1 and table 4, and c^{-1} is an inverted diagonal matrix with the total inputs or outputs shown as c_i. According to our example above, this would result in the following matrices:

$$C = \begin{array}{l} \\ \text{chemicals} \\ \text{plastic} \\ \text{machines} \\ \text{car man.} \\ \text{energy prod.} \end{array} \begin{array}{c} \begin{array}{ccccc} \text{chemicals} & \text{plastic} & \text{machines} & \text{car man.} & \text{energy prod.} \end{array} \\ \left[\begin{array}{ccccc} 5 & 25 & 0 & 2 & 0 \\ 0 & 20 & 0 & 8 & 0 \\ 50 & 15 & 10 & 35 & 100 \\ 0 & 0 & 0 & 17 & 0 \\ 30 & 5 & 15 & 25 & 100 \end{array} \right] \end{array}$$

$$c^{-1} = \begin{array}{l|ccccc|}
 & \text{chemicals} & \text{plastic} & \text{machines} & \text{car man.} & \text{energy prod.} \\
\hline
\text{chemicals} & 1/150 & 0 & 0 & 0 & 0 \\
\text{plastic} & 0 & 1/200 & 0 & 0 & 0 \\
\text{machines} & 0 & 0 & 1/410 & 0 & 0 \\
\text{car man.} & 0 & 0 & 0 & 1/200 & 0 \\
\text{energy prod.} & 0 & 0 & 0 & 0 & 1/815 \\
\hline
\end{array}$$

$$A = \begin{array}{l|ccccc|}
 & \text{chemicals} & \text{plastic} & \text{machines} & \text{car man.} & \text{energy prod.} \\
\hline
\text{chemicals} & 0{,}03 & 0{,}12 & 0{,}00 & 0{,}01 & 0{,}00 \\
\text{plastic} & 0{,}00 & 0{,}10 & 0{,}00 & 0{,}04 & 0{,}00 \\
\text{machines} & 0{,}33 & 0{,}08 & 0{,}02 & 0{,}18 & 0{,}12 \\
\text{car man.} & 0{,}00 & 0{,}00 & 0{,}00 & 0{,}08 & 0{,}00 \\
\text{energy prod.} & 0{,}20 & 0{,}02 & 0{,}04 & 0{,}12 & 0{,}12 \\
\hline
\end{array}$$

These technical input coefficients can be interpreted as follows: for each euro output, the plastic industry needs 0.12 euro of purchases (input) from the chemicals industry, 0.10 euro of purchases from the own industry, … . The sum of the column for each industry is less than one, which can be explained by the absence of added value and import in this table (Coppens, 2006).

Based on the technical input coefficients from equation (5), the impact of a change in final demand on the national economy, taking into account the direct and indirect effects in the whole chain, can be calculated by:

$$L = (I - A)^{-1} \tag{6}$$

With I a corresponding identity matrix and L being the (inverted) Leontief matrix, containing the technical output coefficients for the national economy. According to our example above, this would result in the follow matrix:

$$L = \begin{array}{l|ccccc|}
 & \text{chemicals} & \text{plastic} & \text{machines} & \text{car man.} & \text{energy prod.} \\
\hline
\text{chemicals} & 1{,}03 & 0{,}14 & 0{,}00 & 0{,}02 & 0{,}00 \\
\text{plastic} & 0{,}00 & 1{,}11 & 0{,}00 & 0{,}05 & 0{,}00 \\
\text{machines} & 0{,}38 & 0{,}14 & 1{,}03 & 0{,}23 & 0{,}14 \\
\text{car man.} & 0{,}00 & 0{,}00 & 0{,}00 & 1{,}09 & 0{,}00 \\
\text{energy prod.} & 0{,}25 & 0{,}06 & 0{,}05 & 0{,}16 & 1{,}14 \\
\hline
\textbf{LEONTIEF} & \mathbf{1{,}66} & \mathbf{1{,}45} & \mathbf{1{,}08} & \mathbf{1{,}55} & \mathbf{1{,}28}
\end{array}$$

The Leontief multiplier can be calculated by summarising all technical output coefficients of certain column industry. The result is called the Leontief multiplier for the corresponding industry and it can be interpreted as the total effect on the output of the national economy by a change of one unit in final demand for the concerned industry. In the example, each increase in final demand of the plastic industry by 1 euro, will result in a total output increase of 1.45 euro for the national economy of Belgium.

In addition, the Leontief multiplier can also be used to analyse the impact on the national employment by applying the same multiplier values to the corresponding employment data of each industry. In order to do this, the assumption that needs to be made is that the relation between output and employment remains unchanged when a shift in final demand is taking place (Coppens, 2006).

The **Gosh multiplier** is calculated similarly to the Leontief multiplier, but using the added value and import as an exogenous factor, instead of the final demand. This way, the Gosh multiplier is supply-driven, while the Leontief multiplier is demand-driven. The Gosh multiplier measures the total effect on the output of the national economy by an exogenous change in import or added value for one of the industries. A change of one unit in final demand in industry i results in a total output change expected to be greater than initial change of one unit (Coppens, 2006; Miller & Blair, 2009).

It should be noted that both models are using the assumption that the relations between the industries on one side, and final demand or import and added value on the other side are not changing when the demand or added value is increasing or decreasing (Coppens, 2006).

Finally, Oosterhaven and Stelder (2002) have applied a correction factor to the multipliers which makes it possible to multiply them with the total output without distortion. As such, the total share of generated effects on the total national economy of a whole industry can be calculated without any overestimations. This is the final version of the multipliers that has also been used in the study of economic impact from port activity (Coppens et al., 2007) and it is the multiplier that is proposed to be used in the analysis of this WP.

2.4 Interdependence or linkages of industries

In order to further analyse the relations between industries, three different indicators can be used based on the theory of the Markov-chain and its corresponding attributes: (i) Cai and Leung linkages, indicating the effect of an industry compared to its own output; (ii) decomposed linkages, indicating the effect of an industry compared to the output of the industry of concerned customers or suppliers and finally (iii) key sectors (Coppens, 2007). For the first two indicators, forward and backward linkages can be calculated. Forward linkages estimate the total effect of a certain industry on its customers. Backward linkages are showing the same relation, but for the suppliers of a certain industry. An overview of the formulas for these linkages is given in table 5. Within the formulas, l_{ij} refers to the Leontief technical output coefficients and g_{ij} refers to the Gosh technical output coefficients, which are explained in section 2.3.

These linkages can be calculated between the industries that are taken into account in the input-output analysis. Due to data limitations, which will be explained in section three, the most important relations from the available national input-output analysis will be the relation between the rail freight industry and multiple customers and suppliers. Moreover, intermodal relations with land transport (road freight and pipeline transport), water transport (maritime freight and inland shipping), air transport and storage and supporting activities will be further investigated. Further analysis will need to make clear how national companies are distributed within the national input-output analysis over the different industries that are available, in order to be able to give a correct interpretation and understanding on the different industries involved.

TABLE 5 – INPUT-OUTPUT INDICATORS REGARDING THE RELATIONS BETWEEN INDUSTRIES

Cai and Leung linkages (all levels)	backward	$BL_j = \frac{\sum_{i=1}^{n} l_{ij}}{l_{jj}}$	linkage of industry *j* to its suppliers	in relation to the output of industry *j*
	forward	$FL_i = \frac{\sum_{j=1}^{n} g_{ij}}{g_{ii}}$	linkage of industry *i* to its customers	in relation to the output of industry *i*
Decomposed linkages (all levels)	backward	$BDec_{ij} = \frac{g_{ij}}{g_{jj}}$	linkage of industry *j* to its supplier *i*	in relation to the output of industry *i*
	forward	$FDec_{ij} = \frac{l_{ij}}{l_{ii}}$	linkage of industry *i* to its customer *j*	in relation to the output of industry *j*
Key sectors	$\frac{\text{Leontief multiplier of j} \times \text{final demand of j}}{\text{output of j}} > 1$		sector *j* is more important for the other sectors than vice versa	

SOURCE: CAI & LEUNG (2004), COPPENS ET AL. (2007)

3. RISK ANALYSIS: DATA COLLECTION AND VALIDITY OF THE RESULTS

In the previous section, it is indicated that a national input-output table is dividing the economy into a certain number of industries (Coppens, 2007). The Federal Planning Office is using 64 industry clusters for the Belgian national input-output table of 2010, based on the revised NACEBEL codes from NAI (Federal Planning Office, 2015). As it was mentioned before, a time delay for this kind of data of approximately 5 years has to be taken into account (Federal Planning Office, 2015). Corresponding to our research on rail freight transport, the lowest level of details publicly available in this national input-output table is classification number 49, including all companies active in the field of land transport and pipes transport. This includes both freight and passenger transport. As such, no conclusions can be drawn from this national input-output table for the rail freight industry. In addition, the national input-output table is also limited in terms of comparison of linkages and relations between the different industries, as this could only be done between the included 64 clusters. As a consequence, interesting relations such as the linkage between rail freight transport and shipping agents, freight forwarders, terminals and others transport actors cannot be analysed.

Taking this into account, the main difference between the port study of Coppens et al. (2007) and the current analysis of the rail freight sector and its impact on the Belgian economy should be explained. Whereas the port study is a disaggregate analysis, it is more focussed on the micro-economic level of the port industry. Only companies active within a geographically bound area, being the port of Antwerp, and a limited number of cluster industries, being the port actors, were taken into account. This set of companies was re-clustered in a new set of industries defined by the researchers. Applying the same bottom-up approach to the current analysis would require disaggregate micro-level data about all companies related to rail activities that are active in Belgium, and re-cluster them into an own defined set of industries linked to the rail freight sector. This would be the same work that the Federal Planning Office is doing every five years, although with a different set of industries. The end result would be more of a micro-level analysis of the rail freight sector, without having a full picture of the macro-economic impact on the Belgian economy, which is the main objective of the current research.

Therefore, it should be accomplished to split the rail freight sector from the national classification number 49. In this way, the rail freight industry can be compared with the main national industries of the Belgian economy. According to the methodology described in section 2, this can be done by departing from the original supply – and demand tables for the Belgian economy, and re-clustering companies active in the rail freight industry into a new industry. As such, the rail freight industry is pulled from the land transport and pipes transport industry and can be analysed separately.

In order to obtain this result, a partnership has been started with the National Bank of Belgium and relations have been set-up with B Logistics, the incumbent Belgian rail operator who is still holding a market share of above 80% and therefore representing the biggest part of the rail freight industry in Belgium (Deville & Verduyn, 2012). The objective of this cooperation is to retrieve the necessary data to calculate the input-output analysis and the corresponding multipliers and linkages for the rail freight industry in Belgium.

A last remark with respect to the data is the validity of the results. The national input-output table and the data that will be collected during the research will take into account rail freight operators and their corresponding activities that are registered in Belgium and active on the Belgian geographical territory. As such, rail actions performed by international companies without establishment in Belgium will not appear in the data and will not be taken into account. Although these international operations also have a clear influence on the Belgian economy, the output of the current research should be interpreted as the macro-economic effect of national operations by national companies on the national economy.

4. LINK WITH THE SCENARIOS: TRANSLATION OF TKM AND A SENSITIVITY ANALYSIS

The last published Leontief multiplier by the Federal Planning Office dates from May 2010, being calculated based on the input-output tables for Belgium for the year 2005. Although the input-output tables for Belgium for the year 2010 are also calculated and published in December 2015 (Federal Planning Office, 2015), the Leontief multipliers have not yet been calculated and analysed. As a first step towards the continuation of this research, this has been done as a start for further analysis and an exercise to learn the methodology described above. The results of this exercise can be found in table 6.

TABLE 6 – LEONTIEF MULTIPLIERS FOR TRANSPORT SECTORS (2005 AND 2010 COMPARISON)

Industry (cluster)	Multiplier 2005	Multiplier 2010
Land transport	1.73	1.66
Water transport	1.91	1.63
Air transport	1.82	1.72
Storage and transport services	1.73	1.67

SOURCE: FEDERAL PLANNING OFFICE (2010); OWN CALCULATIONS BASED ON FEDERAL PLANNING OFFICE (2015)

This means that the industry of land transport has an effect of 1.73 on the national economy of 2005 and 1.66 in 2010. As a consequence, each euro increase in final demand in the industry of land transport results in an increase by 1.73 euro and 1.66 euro for the national Belgian economy, for 2005 and 2010 respectively. The decrease can be linked to the economic crisis that started in 2008, lowering the relative contribution of the transport sector to the macro-economic level of a country.

The results for the land transport industry can be compared with other transport industries, such as water transport and air transport. Where air transport provided a higher economic impact in both years, water transport faced a greater drop by 2010 compared to the other transport industries. The industry of storage and transport services is delivering a similar impact to the national economy compared to land transport. It should be emphasised that the land transport sector is mainly represented by road freight and public transport. As such, no direct conclusion can be taken for the rail freight industry.

When comparing to other industries in the Belgian economy, it can be stressed that the construction industry has the greatest impact on the national economy. With a multiplier of 2.14 in 2005 and 2.06 in 2010, each euro increase in final demand for the construction industry is resulting in more than an additional euro worth of indirect effects. The industry with the lowest effect on the national economy is education, with a multiplier of 1.12 in 2005 and 1.14 in 2010.

Looking at the strongest and weakest links for the industry of land transport, a first analysis shows that strongest link exists with the industry of storage and transport services, as well as legal services, leasing and the production industry of cokes and oil. The weakest link of land transport in terms of indirect output effects exists with the pharmaceutical industry and agriculture. It should again be mentioned that this analysis is based on aggregated data for the land transport sector as a whole, and therefore no conclusions can be drawn yet for the industry of rail freight transport.

After the calculation of the macro-economic impact of the rail freight industry on the national economy, the results of WP 3 will be linked to the scenarios developed in WP 1. Within this first WP, three different scenarios have been defined based on a SWOT that was performed for the rail freight sector. These scenarios are created by a set of parameters, indicating a worst-case evolution, a medium-case evolution and a best-case evolution for rail freight transport by 2030. As the model to measure the macro-economic impact is demand-driven, the parameter indicating the realised amount of ton-kilometre (tkm) will be of main importance for WP 3.

Based on the evolution of the amount of rail tkm in the three scenarios, the impact on the national economy can be estimated by applying this new demand to the collected data that was found for the analysis of the current state of the rail freight sector in terms of impact on the national economy. For the best-case scenario, an increase of rail freight demand by 133% is estimated. For the medium-case and worst-case scenario, this is respectively set to 64% and 10%. Taking into account the set growth parameters for the national economy in the corresponding scenarios, the data of the national supply –and demand tables and the data of the rail freight industry can be adapted accordingly, and the impact on the multipliers and linkages between the industries can be analysed.

By applying these scenarios to the set of data, in a first stage, the assumption is made that the relations between the sectors will remain unchanged. Therefore, a sensitivity analysis can be performed, in which different conditions are released and tested, to measure the influence on the outcome of the model. For example, one parameter could be the impact of the capacity, which is excluded from the first analysis, but can be verified in a second stage as this might become a bottleneck when rail freight demand is increasing.

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DELIVERABLE 4.1: Methodology proposal for the sustainability impact of intermodality

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In 2011, the European Commission decided that by 2030, 30% of road freight over 300 km in Europe should shift to other, more energy-efficient modes of transport, such as rail or waterborne transport (European Commission, 2011). In Belgium, road transport was responsible for 58.3% of the total inland freight expressed in tonne-kilometres in 2012, representing the dominant mode of the three major inland transport modes. Inland waterways accounted for 24.3% and rail transport for 17.5% (Eurostat, 2015).

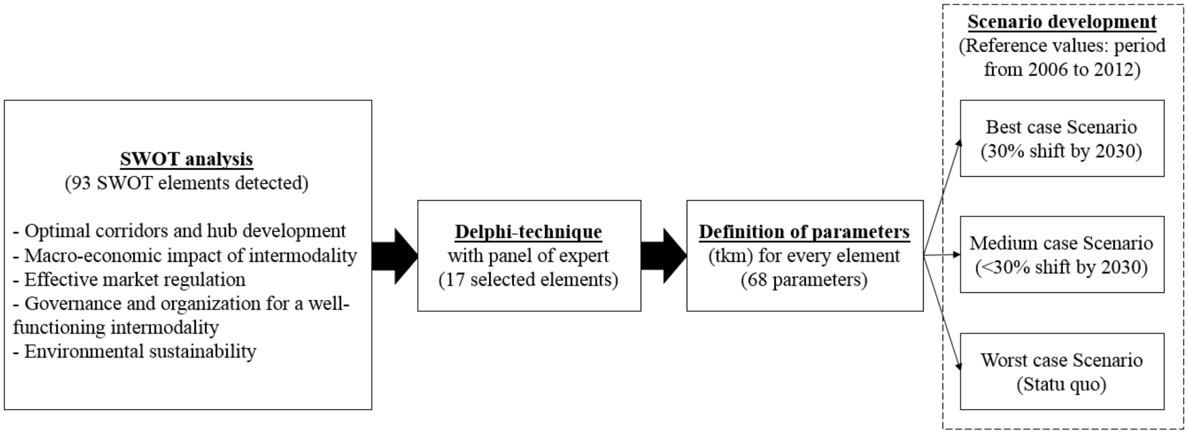
The BRAIN-TRAINS project deals with the possible development of rail freight intermodality in Belgium from an interdisciplinary perspective, focusing on five main subjects: optimal corridors and hub development, macro-economic impact of intermodality, effective market regulation, governance and organization for a well-functioning intermodality, and environmental sustainability of intermodal rail freight transport.

In order to identify the current state of intermodal rail freight transport in Belgium, a SWOT analysis was performed related to the five different fields of this study. The most important elements in terms of impact and likelihood of happening in the future identified in the SWOT analysis have been selected through a Delphi-technique with the collaboration of a panel of experts. Then, by clustering the interrelated elements, a final selection of 17 SWOT elements related to intermodal rail freight transport has been achieved. The 17 final identified elements have been translated into clear and measurable parameters for the scenario development, defining for every parameter an input value to quantify the scenarios. Furthermore, all processes are analysed in the same unit of measurement, chosen as “tonne-kilometre (tkm)”, which represents the transport of one tonne of goods over a distance of one kilometre (Vanelslander et al., 2015).

One of the selected elements from the SWOT analysis is the “strength of rail transport to reduce costs and externalities”. This element contains five measurable parameters, being four of these parameters related to the environmental aspect of the rail freight transport: transport emissions (CO_2 emissions and other emissions), energy consumption and noise exposure.

Finally, three divergent Belgian scenarios with a time frame set in the year 2030 have been built for further analysis (see figure 1). These scenarios are directly linked to the third strategic goal of the European Commission’s White Paper on transport (2011), which aims to shift the 30% of road freight over 300 km to other modes such as rail transport by 2030. As a result, a best, worst and medium case scenarios have been developed, depending on whether the 30% shift will have been successfully accomplished, the status quo will have been maintained or the goal will not have been completely reached by 2030, respectively (Troch et al., 2015).

FIGURE 1. SCENARIO DEVELOPMENT PROCESS IN THE BRAIN-TRAINS PROJECT



SOURCE: OWN COMPOSITION BASED ON TROCH ET AL., 2015

The Life Cycle Assessment (LCA) methodology has been chosen to analyse the sustainability impact of rail freight intermodality. The LCA methodology allows studying complex systems like intermodal transport providing a system perspective analysis that allows assessing environmental impacts through all the stages of the rail freight system (rail transport operation, rail equipment and rail infrastructure), from raw material extraction, through materials use, and finally to disposal. The continuous development and improvement of this methodology allows it to be up-to-date and to be a reference to model in a quantitative and multi-criteria way the environmental impacts of several pollutants in numerous categories of railway freight intermodality (Merchan et al., 2016).

The purpose of this deliverable is to explain the methodology used to determine the environmental impacts of rail freight intermodality for several Belgian scenarios using the LCA methodology.

1. PROBLEM IDENTIFICATION

Intermodal and rail freight transport in Belgium do not have a prominent position compared to other European countries (Van de Voorde and Vanelslander, 2014). Intermodal rail freight transport has several strengths that can lead it to grow, such as the reduced cost that can be obtained due to the high payload capacity of trains as well as reduced externalities compared to road transport due to decreased emissions and improved road safety (Crozet et al., 2014). Nevertheless, intermodal rail freight transport presents some weaknesses due to its dependence on rail infrastructure, resulting in missing direct rail links, weak access to the rail network or a lack of flexibility (Vanelslander et al., 2015).

Despite the fact that environmental impact studies on intermodality transport show that rail freight transport is the land transport option that has the best environmental performance (Facanha and Horvath, 2006; Fries and Hellweg, 2014; Hendrikson et al., 2006), especially when electrified railway is used (Spielmann and Scholz, 2005), road transport is more flexible with a more extended network and direct links, causing the dominant use of road-rail intermodal transport (Demir et al., 2015). LCA studies demonstrate the importance of all life cycle phases (infrastructure and vehicle life cycle) and not only modelling fuel combustion for the assessment of transport.

Even if generic commercial databases as Ecoinvent (Weidema et al., 2013) are available, there are no Belgian specific commercial transport databases and current databases should be improved and updated. The existing databases allow performing a preliminary search to guide us in identifying the most influential factors in the environmental impact of freight transport (Spielmann and Scholz, 2005). We have used as a model the Swiss transport database included in Ecoinvent database, which is the most comprehensive transport database available. It should be noted that rail freight transport in Switzerland is mainly done with electric traction, which is not the case in Belgium, where a combination with diesel traction appears (see table 1).

TABLE 1. ELECTRIC AND DIESEL RAIL FREIGHT TRACTION SHARE IN FLANDERS.

Year	1990	2000	2004	2007	2008	2009	2011	2012	2013
Electric traction	61%	61.2%	77%	76%	78.2%	83.1%	83.8%	86.3%	85.2%
Diesel traction	39%	38.8%	23%	24%	21.8%	16.9%	16.2%	13.7%	14.8%

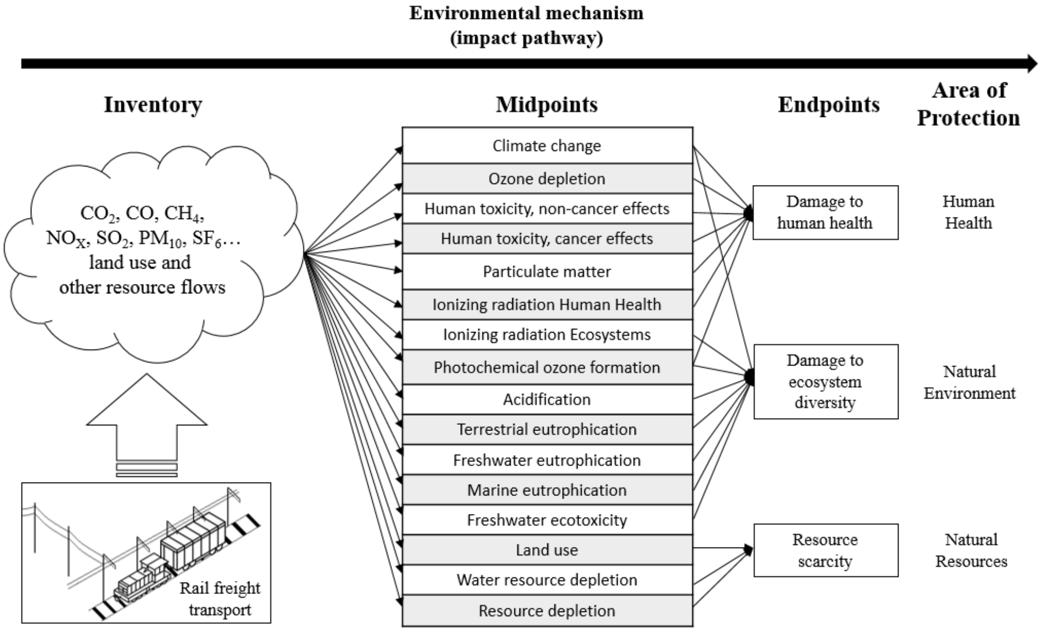
SOURCE: VMM, 2005, 2006, 2007, 2008, 2009, 2010, 2012, 2013 AND 2014

Currently, there is no publication relative to the state-of-the-art for Belgian freight transport and technical data (machine type, tracks, capacity or energy supply for example), having a lack of data for the assessment of transport impacts and concerning building infrastructure. For data collection, more reliable sources of information have been identified and we will collect information through interviews with different stakeholders, such as B Logistics, which is the main operator in Belgium with a market share of 86.62% of tkm in 2012 (Van de Voorde and Vanelslander, 2014) and Infrabel, which is the Belgian railway infrastructure manager.

2. METHODOLOGY

The environmental impact of rail freight intermodality is determined using the LCA methodology. LCA is a structured, comprehensive and internationally standardised method by ISO Standards 14040 and 14044 (International Standardization Organization, 2006), and using the ILCD Handbook (European Commission, 2010) as a reference to perform an LCA. LCA methodology allows quantifying all relevant emissions and consumptions, as well as the related environmental and health impacts and resource depletion issues that are associated with rail freight intermodality. Thus, through the application of the LCA methodology, the contribution of the pollutants emitted by rail freight transport can be analysed using midpoint environmental impact categories, such as climate change, resource depletion, acidification, human toxicity or ecotoxicity for example. Then, as can be seen in figure 2, the influence of these midpoint categories to endpoint categories such as damage to human health, damage to ecosystem diversity and resource scarcity can be evaluated. These endpoint categories are related to the areas of protection of human health, natural environment and natural resources, respectively (European Commission, 2010).

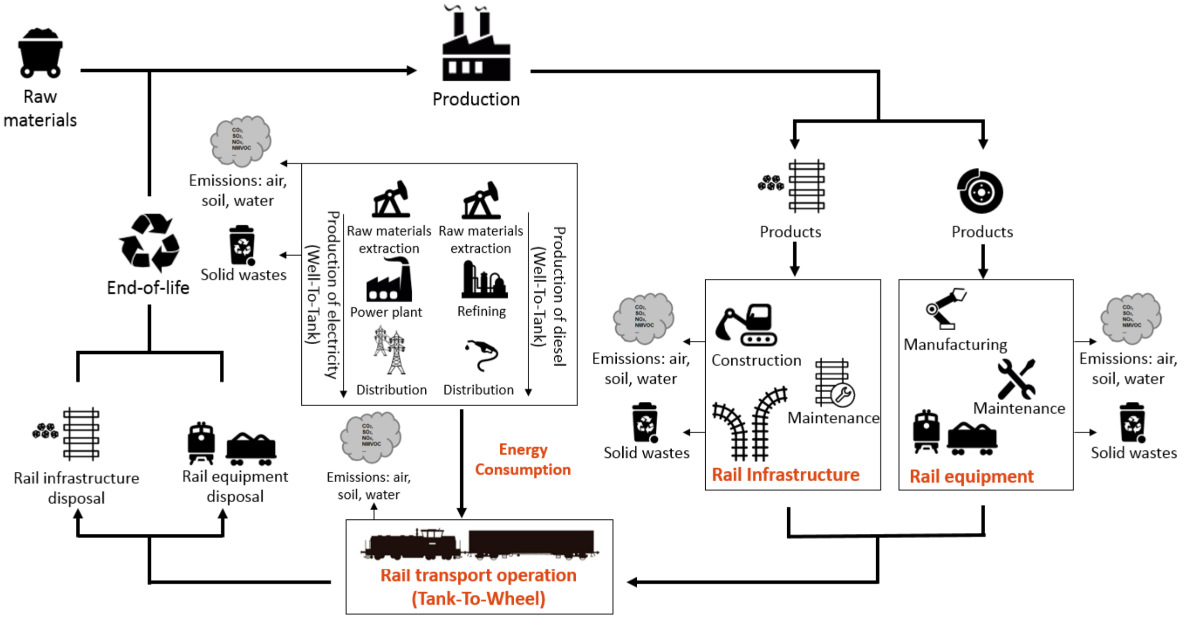
Figure 2. Diagram of the Life Cycle Impact Assessment methodology applied on rail transport.



Sources: European Commission, 2010 and Sala et al., 2012

As shown in figure 3, the rail freight system has been divided in three sub-systems: rail transport operation, rail infrastructure and rail transport equipment (locomotives and wagons). The application of LCA methodology to rail freight transport allows analysing not only the transport emissions related to the energy consumption during the operation of the train (direct emissions from diesel locomotives or emissions from electricity generation when electric locomotives are used), but also the emissions related to the construction and manufacturing of rail infrastructure and rolling stock, and maintenance and disposal of both sub-systems (Spielmann et al., 2007).

Figure 3. Railway system boundaries.



Source: Own elaboration

2.1 Rail transport operation

The sub-system ‘rail transport operation’ includes direct and indirect processes that are connected with train activity. Direct processes include the specific energy consumption and the amount of transported freight depending on the train traction, thus considering diesel and electricity traction separately. In addition, it has also been included as direct processes both the direct emissions to air related to the diesel combustion in locomotives such as CO_2, CO, NO_x, SO_2, NMVOC or particles emissions for example, and the direct emissions to soil from abrasion of brake linings, wheels, rails and overhead contact lines. Finally, people exposed to noise due to rail freight transport activity is also included as a direct process. Indirect processes of the sub-system rail transport operation include the upstream energy consumptions and emissions related to the production and distribution of diesel and electricity used in the rail transport operation. In order to determine direct and indirect emissions mentioned above, the appropriate emission factors have been calculated.

Emissions from the rail freight transport activity are produced at different stages depending on the type of energy used (see figure 2). For diesel traction, main emissions are produced as exhaust emissions during the vehicle operation activity in the Tank-To-Wheel (TTW) stage, when the combustion in the engine is produced. It should be noted that during oil extraction and refining, emissions are also produced. For electric traction, main emissions are produced during the electricity production at power plant in the Well-To-Tank (WTT) stage.

In our study, the LCA approach will be used, taking into consideration the overall life cycle of the energy carrier which means that, in addition to the emissions of the combustion, (TTW stage for diesel and WTT stage for electricity), the emissions of the supply chain are added. They include emissions from extraction of raw materials, refining and distribution of diesel and production and distribution of electricity. The LCA methodology can provide complete information of the environmental impacts related to a process, and not only providing information on energy consumption and emissions produced but also on raw materials consumption.

For the BRAINTRAINS project, the specific energy consumption during the rail transport activity of electric and diesel trains has been determined separately on the basis of the total annual energy consumption of electricity and diesel and the total annual rail freight moved by each energy traction from the period 2006 to 2012. Then, the specific electricity and diesel consumption for a mixed electric and diesel traction is determined. Finally, the final electricity and diesel consumption taking into account the electricity losses and the shunting activity is calculated.

Direct emissions produced during the rail transport activity have been determined. The exhaust emissions to air related to the diesel combustion in locomotives are calculated using the emission factors of Spielmann et al. (2007) and the previously calculated diesel consumption. To determine particle emissions, it is necessary to add the particles produced by the abrasion of wheels and rails to those produced by the combustion of diesel. It should be noted that the sulphur hexafluoride (SF_6) emitted during conversion at traction substations is related to electricity consumption and not to diesel consumption.

Some points to improve the efficiency of the rail freight transport could be studied such as the reduction of energy consumption through the weight reduction of locomotives and wagons and the reduction of emissions using a cleaner electricity or replacing diesel by other sources of cleaner energy as biodiesel in diesel locomotives. Note that the use of biodiesel produces advantages in terms of CO_2 emissions, but analysing the life cycle of the biodiesel the pollution could be transferred from air when combustion to soil and water during crop production.

Therefore, the environmental advantages of the use of biodiesel depend on the specific type and source of the biodiesel.

A decrease in diesel traction of the rail freight transport in Belgium (13.7% of rail freight transport in 2012) should lead to a reduction of exhaust emissions. However, the complete replacement of diesel traction by electric traction is difficult, because Belgium is mainly an exporter and importer of goods rather than a transit country. This activity causes a large shunting activity performed by diesel locomotives.

2.1.1 Electric traction

The energy chain of electricity carrier comprises the raw material extraction (coal, oil, gas or uranium for example) and its transport to the power plant, the energy production process within the power plant including its construction and disposal and the energy distribution including transforming and cable losses (EcoTransIT, 2008).

The domestic production mix and the supply mix of electricity in Belgium have been distinguished. The domestic production mix is the country-specific production without taking into account exports or imports of electricity. The supply mix is the domestic production mix including exports and imports. Therefore, the electricity supply mix of a country has a different energy split than the domestic production mix, because the different energy split of the exporting countries. The electricity imports from France, the Netherlands and Luxembourg have been modelled considering the supply mix of the exporting countries.

In order to adjust as closely as possible the environmental impact related to the yearly electricity consumption, and since the electricity supply mix is different every year, our LCA study uses the electricity supply mix in Belgium corresponding to the appropriate year (from 2006 to 2012) according to Eurostat data.

Eurostat data allows distinguishing between auto-producers of electricity (which generate electricity for their own use) and main activity producers, which generates electricity as their principal activity and transferring this electricity through the high voltage network. Therefore, only the electricity generated by main activity producers can be used by rail transport, since the rail network uses high voltage electricity. Moreover, solar energy generated by Infrabel since 2011 is also taken into account. Distribution losses in the high voltage network and transmission losses during conversion in traction substation and transport via the overhead contact line in the Belgian railway network are considered.

2.2 Rail infrastructure

The subsystem 'rail infrastructure' includes the processes that are connected with the construction, renewal and disposal of railway tracks, tunnels, bridges and the railway electrification system. Information has been collected relative to rail infrastructure such as tunnels and bridges of the rail network, materials and energy used in the construction (rails, sleepers, fastening systems, switches, track bedding or electrical installations for example), renewal (replacement of materials and maintenance works), disposal of tracks (e.g. wood sleepers and ballast) and land use in the Belgian railway network.

Common use of infrastructure between passengers and freight transport entails the difficulty of the distribution of each impact between each type of transport. For rail infrastructure, allocation between passenger and goods transport is unavoidable (Spielmann and Scholz, 2005). The allocation factor for construction and disposal activities are calculated using the gross tonne-kilometre (weight of wagons and goods) per year for passengers and freight transport and the allocation factor for operation services will be determined using the annual vehicle-kilometres performance for passengers and freight transport (Spielmann et al., 2007).

2.3 Rail equipment

The subsystem 'rail equipment' stage includes the processes that are connected with the vehicle life cycle (locomotives and rail wagons, excluding the operation) currently used such as manufacturing (e.g. material composition of goods wagons), maintenance (consumption on wheels, break shoes, paint, cleaning agents or lubricates for example) and disposal of materials due to maintenance activities or end-of-life of transport locomotives and wagons (Spielmann et al., 2007).

3. LINK WITH THE SCENARIOS AND PERSPECTIVES

As indicated previously, the LCA methodology allows quantifying the transport emissions generated by the overall rail freight transport system. Furthermore, the LCA methodology allows obtaining as output from our study the contribution of the emissions to different midpoint or endpoint environmental impact categories (see figure 2).

The environmental impact related to the parameter energy consumption depends on the proportion of use of electric and diesel traction in Belgium. Moreover, the environmental impact related to electricity consumption depends on the energy split of Belgium. Therefore, in order to develop the scenarios, it is necessary to know the proportion of use of electric traction and the electricity supply mix in Belgium with a time horizon in 2030. The energy consumption and direct emission results from the period 2006 to 2012 are taken as reference values to develop the three divergent Belgian scenarios.

The LCA results of the complete rail freight system, including operation, infrastructure and equipment, will be used to update and improve the accuracy of existing commercial databases. One of the aims of the study is to develop a transport database specific to Belgium to allow for a better modelling of the obtained environmental impacts and to improve the regionalization of the results.

The results obtained in this research will define the sustainability impact of future intermodal transport. They could help in making optimised policy decisions relative to the development of intermodal transport in Belgium, including environmental aspects and allowing the reduction of emissions in the transport sector.

A comparison between the environmental impacts related to rail freight transport, inland waterways transport and road transport will be performed. For rail freight transport, the model obtained from the complete BRAINTRAINS study presented in this paper will be used. In the case of both inland waterways transport and road transport in Belgium, we will use as a model the Ecoinvent database. Information relative to the total annual freight moved by inland waterways transport in Belgium by barge type, fuel consumption in the vessel transport operation and waterways infrastructure characteristics for several years will be collected. Similarly, information relative to the total annual freight moved by road transport in Belgium by heavy duty vehicle technology type, fuel consumption in the road transport operation and road infrastructure characteristics for several years will be collected.

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DELIVERABLE 5.1: Methodology proposal for the regulation policy

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Work package (WP) 5 provides tools from economic regulatory theory, in order to increase the share of the rail freight mode in the intermodal chain in Belgium. The liberalization of the rail freight market in 2007 changed deeply the market structure and the levers for policy makers to support it. The objective of this package is to determine the conditions to ensure a good level of competition on the Belgian rail freight market. The method is based on the industrial organization approach and has two challenges: to assess the risk of concentration of competitors on the Belgian market and to define the levers for Belgian authorities to manage the market.

The main components of the methodology are:

1. Problem identification: which market to regulate?
2. Data collection: limit of traditional databases
3. Methodology: tools for a market analysis
4. Link with the scenarios: grid for market regulation

1. PROBLEM IDENTIFICATION : WHICH MARKET TO REGULATE?

A first step in the regulatory analysis is to define the relevant market and its characteristics. In the case of the rail freight market, there are two main challenges: the product market definition and the geographical market definition.

1.1 The product market definition: A multi-product market in competition with other modes

The product market definition depends on the level of substitution or complementarity between goods categories by firms. It can be defined by the cross-price elasticity[1] of demand (CED) according to Lipczynski *et al.* (2013).

The rail freight market has several dimensions. First, the industry is strongly linked to other transport modes: road and inland navigation. Literature shows that the cross-price elasticity is often superior to one between road and rail (Oum, 1979; Abdelwahab, 1998; Beuthe *et al.*, 2001; McKinnon, 2005). Road has an advantage on the short haul while rail has an advantage on the long haul (Oum, 1979). Thus, cross-price elasticity is the highest between road and rail on medium haul (150-300km).

Second, the rail freight sector can be defined as a multi-product industry (Cantos and Campos, 2005). Services are different according to the customers and products. At the first level, a distinction is made between intermodal traffic (mainly containers) and conventional traffic, i.e. block trains and single wagons (Bozicnik, 2009). Logistics requirements are different according to each level of service. Intermodal traffic needs a high frequency, while conventional traffic needs reliability (just on time). At a second level, a distinction exists

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[1] The cross-price elasticity measures the percentage change in price for the first good that occurs in response to a percentage change in price of the second good

according to the nature of the goods transported. Operational rules and rolling stock are totally different if the service is dedicated to chemical products or rubbles for instance.

Consequently, the rail freight market has to face a double handicap. On the one hand, there is a high substitutability on the short and medium-haul with road transport. Competition can particularly be strong with inland navigation (Beuthe *et al.*, 2001; Crozet, 2016). On the other hand, the rail freight market is highly segmented with diverse type of services, logistics and technical requirements.

This WP5 considers the rail freight market in its entirety. No distinction is made between different market segments, mainly because data are too aggregated for this level of analysis, but also because most operators are active on several segments of the market.

1.2 The geographical market definition: A multi-scale market between Europe and national markets

The geographical market definition is the second key element in a market analysis. Selecting the relevant geographical scope is essential to determine the size of the market and to measure the market power of firms. The method proposed by the literature is similar to the product market definition (Lipczynski *et al.*, 2013). The cross-price elasticity is spatial. The higher the elasticity, the more both places are linked together. In practice, it is difficult to circumscribe the relevant market mainly in the case of the rail freight industry (Mitusch *et al.*, 2014).

First of all, there is a persistence of national markets in spite of the single market wanted by the European Commission. Laroche & Guihery (2013) show through the implementation of the new European Rail Traffic Management System (ERTMS) that the European network remains strongly fragmented between different national networks with different languages, track gauges, signaling systems, etc. These differences constitute a strong barrier to intra-European competition and tend to reduce the cross-price elasticity between the different parts of the European network.

The second difficulty comes from the lack of consensus on the European rail freight market in the literature. Most authors consider the political borders of the EU (including Norway and Switzerland) as the relevant market. Nevertheless, some authors limit the scope of the European market to some countries according to their data (see e.g. Cantos and Maudos, 2001; Friebel *et al.*, 2010) or extend it to the Far East and South-East Europe (see e.g. Hilmola, 2007). Mitusch *et al.* (2014) show that another approach is possible through the analysis of rail freight flows in Europe. They find that most traffic is concentrated around an axis between the Northern European and Southern European ports, and they propose *in fine* a dynamic scope of the European market.

Consequently, there is no consensus on the relevant scope for the European rail freight market. It remains highly fragmented between national networks in spite of the single market and the real of flows can be different from the political borders.

This WP5 defines the market scope according to the flow approach (Mitusch et al., 2014). Selected countries are mainly concentrated around the “blue banana” and on the Western part of the EU (Cf. annex 1).

2. DATA COLLECTION: LIMIT OF TRADITIONAL DATABASES

Data collection is one of the most important parts to improve our knowledge of the market. In the case of the rail freight market, data are sparse because of the entry of new operators and the limits of traditional databases (Eurostat, UIC, etc.).

2.1 Limits to traditional databases

Usually, two databases are used for the rail freight market in Europe: UIC and Eurostat.

The UIC database is limited to an incomplete overview of the market. First, only incumbents are included. Second, since 2009, data are very sparse because of the liberalization. Consequently, the UIC database is insufficient to describe the evolution of the freight market since 2007.

Eurostat gives interesting and frequently updated time series. Unfortunately, these are only at an aggregate level (Europe/countries) and mainly limited to traffic or aggregated market share for new operators.

Ultimately, existing databases need to be adapted with key data to assess the firm size for all operators included in the top 20-30 (tons-km, tons, turnover, etc.) similar to the US databases.

2.2 Heterogeneous sources

Facing the lack of data from official databases for railway transport, sources are heterogeneous. Concerning the identification of active operators on each network, data come mainly from national network managers (list of active operators) except for Germany, where own identification and classification had to be done from databases of the transport ministry. In this way, the newly developed list is limited to data available for as many active players as possible.

Concerning the second part of the characterization, data come from the European Amadeus database[2] for turnover (in €), and from operator websites or annual reports for specific data (tons-km, trains-km, tons, etc.).

Thus, qualitative data are more comprehensive for all operators, while quantitative data are more limited because of their strategic sensitivity for a lot of operators.

3. METHODOLOGY: TOOLS FOR A MARKET ANALYSIS

Our methodology is based on two classical approaches used to analyze the market structure (Lipczynski *et al.*, 2013): the static and the dynamic approaches. Each approach is characterized by a large panel of indicators. The selection of the following indicators has been done according to the available data.Sys (2010) shows that this methodology might also be applied to other business segments of the liner shipping industry (e.g. bulk transport, tanker segment as well as terminal operations) or other transport modes.

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[2] This database contains comprehensive information on around 21 million companies across Europe. A license is necessary to get data.

3.1 The static approach : absolute concentration

The static approach is useful to give a picture of the level of concentration on the market. Traditional measures are the number of firms and the distribution of the size of firms on the market (Sys, 2010). Indicators used to measure the level of concentration are traditionally split in two kinds of measures: absolute and relative concentration. Unfortunately, because of imperfect information on the market, only the absolute concentration can be measured.

The absolute concentration is usually measured by four indicators: the n-firm concentration ratio (CR), the Herfindahl-Hirschman index (HHI), the Hannah and Kay index (HKI) and the entropy coefficient. In this study, only the two first are used because of data availability. Indeed, the latter two require data for all firms in an industry, while CR and HHI only need data for the biggest firms.

The n-firm concentration ratio is a simple indicator to identify the existence of an oligopoly.

$$CRn = \sum_{i=1}^{n} s_i \tag{1}$$

It does not need extended data and is calculated based on the market share (s_i) of the n biggest firms (CR2, CR4 and CR8). CR4 is most often used and considers only the four first companies in the top ranking. When CR4 > 25% of market share, the literature shows the existence of a loose oligopoly (Shepherd, 1999; Martin, 2002). When CR4 > 60%, there is a tight oligopoly with a high risk of over-concentration and collusion between the biggest firms.

The HHI is the usual indicator to have an overview of the level of concentration on the market according to the weight of each firm (squared market share, s_i).

$$\mathrm{HHI} = \sum_{i=1}^{n} s_i^2 \times 10{,}000 \tag{2}$$

There is a monopoly when HHI = 10,000 and a high concentration on the market when HHI > 1,800. (i.e. Shepherd, 1999)Concentration is low when HHI < 1,000.

3.2 The dynamic approach : POP analysis and C/L ratio

The dynamic approach gives a time perspective of the market. It is composed by two indicators: the Persistence Of Profit (POP) to assess the degree of competition in the short run and long run, and the Capital cost/Labor cost ratio (C/L ratio) to measure the economies of scale and to give an overview of the market structure of the European rail freight market.

3.2.1 The Persistence Of Profit analysis

The POP-method has been developed to give a dynamic approach of the firm behavior on the market (Cable and Mueller, 2008). The indicator measures the firm’s standardized profit rate ($\pi_{i,t}^{s}$) according to that firm’s profit rate ($\pi_{i,t}$) minus the average industry profit rate ($\overline{\pi}_t$). The standardization (average profit rate of all firms) excludes the macroeconomic effects in so far as all firms are affected by the same economic environment.

$$\pi_{i,t}^{s} = \pi_{i,t} - \overline{\pi}_{t} \tag{1}$$

On this base, a first-order autoregressive model is formulated and commonly used for each firm as follows:

$$\pi_{i,t}^{s} = \alpha_i + \lambda_i \pi_{i,t-1}^{s} + \varepsilon_{i,t} \tag{2}$$

The main interest from this indicator is to test the correlation between the profit rate of one year comparing to the previous year in the short run (λ_i) and the long run ($\pi_{i,t-1}^{s}$). In the short run, a POP rate (λ_i > 0) is a sign of barriers or dominant position driver of abnormal profit (above the norm). But, when λ_i = 0, there is no persistence of profits (quick erosion), which is a sign of high competition and low barriers in so far as all firms compete on a same and homogeneous market.

In the long run, a positive (negative) α_i can be the sign of a competitive (non-competitive) position for certain firms when their profit rate is above (below) the norm. However, it can be also the sign of a niche market with less competition and high barriers or a strategy from a dominant player to keep market shares (Sys, 2010). The interpretation of $\pi_{i,t-1}^{s}$ is clearer in the long run according to the degree of convergence between the firm's profit rates. When $\pi_{i,t-1}^{s}$ = 0, firms are limited in their strategy to get abnormal profits because of high competition and low barriers. Consequently, a convergence between different firms' profit rate is observed. Conversely, when $\pi_{i,t-1}^{s}$ ≠ 0, there is lower or no convergence. This is the sign of heterogeneity into the market with high barriers and a niche market where abnormal profits persist. The above observations are summarized in Table 1.

To resume, the conditions of perfect competition are found when λ_i = 0, α_i = 0 and $\pi_{i,t-1}^{s}$ = 0 (Lipczynski *et al*, 2013). For other results, values will be discussed according to the existing literature in the next step.

3.2.2 Capital cost / Labor cost ratio (C/L ratio)

Following Meersman *et al.* (2011), the capital-labor ratio is computed to assess the level of economies of scale in the ground handling industry. This indicator, derived from industrial economics, has the advantage of being a good substitute to the calculation of the curve of the long run average costs when data are limited and to give some clues about sunk costs or barriers on the market.

$$R = \frac{C}{L} \tag{1}$$

The capital cost (C) is related to the amortization cost of the material and infrastructures used for production, while the labor cost (L) is related to the cost of employees at full time. The relationship between them can be interpreted as follows: there are economies of scale when R > 0 and no existence when R = 0. Meersman *et al.* (2011) show that an industry with a high intensity of capital has larger economies of scale than an industry with a low intensity. Hence, the capital intensity can be associated to the sunk costs necessary to enter and operate on the market (cost of material, advertising, research & development, etc.). These costs can differ from one market to another according to the type of goods and services. In the case of the rail freight industry, the main costs are usually those of rolling stock and interoperability (especially for locomotives) or authorization to start a service as license and safety certificate (Laisi *et al.*, 2012).

4. LINK WITH THE SCENARIOS: A GRID AND TOOLS TO REGULATE THE MARKET

This last section provides a framework for regulation according to the different scenarios defined in WP1. Each scenario is linked to a specific market structure (defined by tools used in the previous section). Hence, the first point suggests a grid to read the different scenarios and assess the need for regulation. Then, a second point suggests a panel of levers and policies to define a strategy of regulation.

4.1 Reading grid for scenarios

Three scenario were defined in the WP1:

- Scenario 1 (worst case): 2 operators and 8M ton-kms in 2030 (+10%);
- Scenario 2 (medium case): 4 operators and 12M ton-kms in 2030 (+64%);
- Scenario 3 (best case): 10 operators and 17M ton-kms in 2030 (+133%).

In order to define the need for regulation, we suggest the following reading grid.

Table 1: Reading for scenarios

Two situations	**Concentration on the EU market**	**Concentration only on the Belgian market**
Action level	European problem (industry attractiveness)	Belgian problem (market attractiveness)
Goal	Reduce barriers to entry (contestability)	
Authority	European Commission European Railway Agency	Federal State Regulatory agency

Source: own composition

This grid allows specifying each situation in each scenario. In the case of the worst scenario (1), the action level and levers will not be the same if there are two operators on the European market and consequently on the Belgian market or, if there are many operators on the European market but only two on the Belgian market. In the latter case, there is a problem concerning the attractiveness on the market. It can come from too high barriers or from a too small potential of business.

Levers and tools for each level of policy action are discussed in the last section.

4.2 Policy overview to regulate the market

There are two levels of analysis: the theoretical approach (*what we should do*) and the practical level (*what we do*).

4.2.1 Theoretical overview: characterisation of the railway system

From a theoretical point of view, the railway system is a complex case for regulation. Indeed, it concentrates a high number of constraints like:

- The existence of a strong natural monopoly (infrastructure);
- A high level of technicality;
- The existence of strong links between politics and the sector;
- A strong power from the incumbent on the market.

Consequently, the risks of failures in the market are multiple due to a risk of asymmetric information, regulatory capture or discrimination in favour to the incumbent. They require developing a strong institutional system to monitor the natural monopoly (pricing and quality) and indirectly the market.

4.2.2 Practical overview: practice in other European countries

So far, the Brain-Trains project provides practical recommendations for Belgian rail freight. A benchmark is dedicated to the different institutional systems and policies in Europe for rail freight.

The benchmark suggests an extended analysis of the rail freight policy according to:

- The skills of the regulatory agency;
- The setting of access charges (and monitoring);
- The transport policy (Investment choices, taxes, etc.);
- The monitoring of the network manager (performance scheme);
- The monitoring of the rail market.

The benchmark is split between the European and the national approaches. A first analysis concerns the European law to identify what could be done in terms of railway organisation. This analysis is extended to the different possible applications in Europe through the analysis of different national applications.

Then, the comparison will be done with the Belgian regulation to show what the country does in terms of regulation.

Ultimately, recommendations for policy-makers will be drawn to highlight what could be improved to reach a better market monitoring and increase the rail freight modal share.

Countries analysed for the benchmark are similar to Belgium for their market size: The Netherlands, Austria, Denmark and Switzerland.

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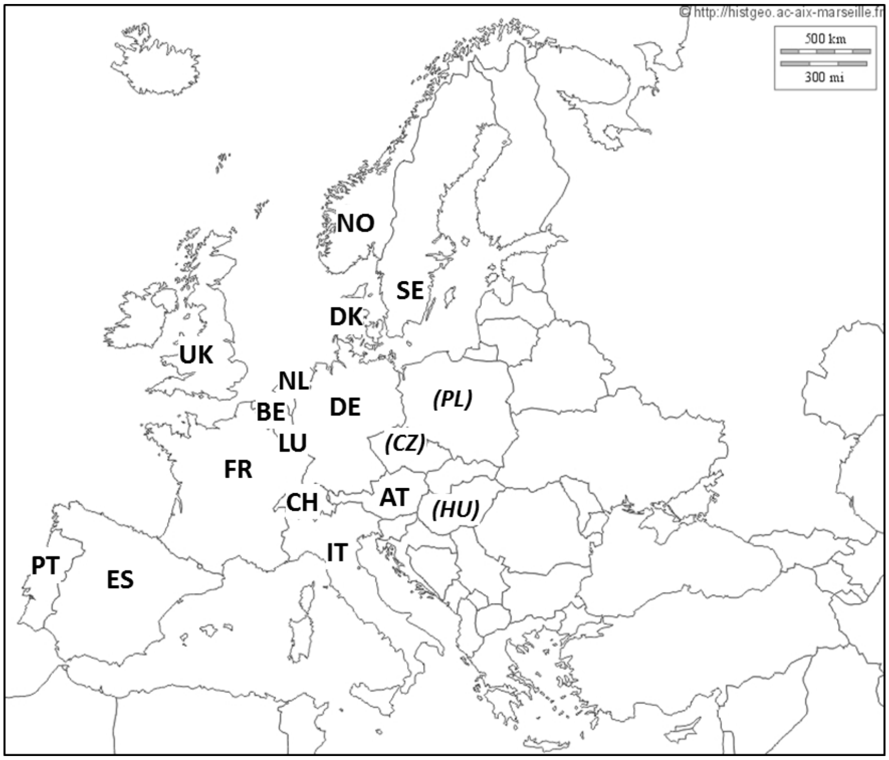
ANNEX 1 : MARKET SCOPE



Source: Own composition

DELIVERABLE 6.1: Methodology proposal for an analysis on effective policy-making for a well-functioning intermodality

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The BRAIN-TRAINS project has the goal to develop a blue print establishing the detailed criteria and conditions necessary for generating an innovative intermodal network in and through Belgium as a part of the Trans-European Transport Network (TEN-T). In the first phase of the project (WP1), the consortium developed three possible future scenarios with an outlook of 15 years (2015-2030). Next, each of the research groups that are a part of the interdisciplinary research team, on the basis of their expertise, will investigate how the scenarios can be turned into reality.

This paper elaborates on the chosen methodology of work package 6 (WP6). The central question in WP 6 is:

> *“How should public administration and policy-making be organized and coordinated to optimally implement intermodality under each of the future development scenarios?”*

In WP6, we specifically look at what mixture of coordination mechanisms and instruments (i.e. coordination architecture) is necessary to ensure, both at the *administrative* as well as the *policy-level*, the uptake of intermodal transport in the possible future situations by 2030. We continue as follows. The next section elaborates on the problem identification. Section 3 outlines the methodology. Lastly, section 4 gives some outlook with regard to what to expect as ‘final’ results.

1. HOW TO ENSURE ‘INTEGRATION’?

The idea of combining transport modes for sustainable purposes (‘intermodal transport’) *challenges* the ordinary practices of public sector organizations in the Belgian federal state. Whereas most actors are used to focussing on the distinct policy problems of the separate modes of freight transport (i.e. rail freight transport, inland navigation and transport by trucks) within their organizational silos, intermodal freight transport demands them to address the issue of freight transport in a comprehensive manner.

In Belgium, however, competences regarding freight transport are scattered across a multitude of organizations from both the federal and regional levels of government (Wallonia, Brussels Community and Flanders). These are exclusive, equivalent material competences, without any hierarchy. This means that each governmental level exercises the power accorded to them without any, or with only limited, interference from actors of other levels of government. Or stated differently, departments and agencies from the different governmental levels are more accustomed to the idea of working *alongside* each other than working *together* (Stevens and Verhoest, 2016). In addition, also organizations from other policy sectors (e.g. environment, spatial planning, economic affairs, health, etc.) which are indirectly related to freight transport policies are often included in the policy processes, so as to avoid negative spill-over effects or policy duplications. *As such*, the research puzzle that we address in WP6 is **how to ensure a suitable level of ‘integration’ among a multitude of organizations from different levels of government and policy sectors in the complex (and competitive) dualistic federal system of Belgium for an intermodal transition in freight transport.**

The concept of ‘integration’ should here be interpreted as “the types of relationships and interdependencies that exist among a multitude of organizations within a particular policy subsystem, such as the transport policy domain in order to achieve coherence in policies and implementation.” A constellation of actors can, for example, be tightly or loosely coupled or clustered. In this research, we distinguish between *policy-level* and *administrative* integration. ***Policy-level integration*** refers to the extent to which political actors try to create greater coherence in decision-making for issues that transcend the boundaries of established policy fields, and which do not correspond to the institutional responsibilities of individual departments and agencies (Meijers and Stead, 2009). ***Administrative integration*** denotes the extent to which involved departments and agencies streamline practices and activities in the policy implementation phase (Mulford and Rogers, 1982).

Our research strategy in WP6 is to distil from the constructed future scenarios of WP1 what the most suitable levels of *policy-level* and *administrative* integration are. Subsequently, we compare these preferred levels of integration to the current state of affairs (both *administratively* as well as *politically*). Together, these assessments allow determining how much discrepancy exists between the *current* administrative and policy-level integration among the public sector organizations in the transport domain and the preferred levels according to each of the scenarios. Depending on the observed discrepancies, we come up with recommendations about how *public administration and policy-making should be organized and coordinated to optimally implement intermodality under each of the future development scenarios. In the next sections, we go into more detail on our research strategy and methodology.*

2. METHODOLOGY

Our research approach and methodology can thus be split into three parts. One part examines the current level of administrative and policy-level integration between actors for freight transport. The second part identifies the preferred levels of integration per scenario. The final part develops and models the needed changes, capacities and instruments at the policy and administrative level for managing the intermodal freight transport transition. We elaborate on each of these parts in the next paragraphs and we discuss how all three parts eventually fit together.

2.1 Current level of administrative and policy-level integration

To gain a notion of the current administrative and policy-level integration in the transport domain, we analyse two cases. First of all, we analyse the attempt of the Federal Department of Transport and Mobility to establish a holistic government strategy encompassing the different levels of government and policy sectors for sustainable and intermodal mobility and (freight) transport. This policy process already started in 1997 and finished around 2010; however, without a successful result. After 13 years, the involved actors did not succeed in *aligning* their governmental and organizational strategies in the pursuit of one common goal – ‘making the sector more *sustainable*’. On the basis of a document analysis and interviews with relevant stakeholders, we try to map the development of the case and to come to a list of factors that have defined why it has been difficult to develop and implement this particular holistic government strategy across the different levels of government in the Belgian dualistic federal state (e.g. the competence division, influence from European Union, inclusive communication, etc.).

The second case is a more contemporary one, and thereby enables us to review current patterns of administrative organization ('administrative integration') and decision-making ('policy-level integration') in the transport domain. Particularly, we examine the transposal of the Intelligent Transport Systems (ITS) directive (2010/40/EU). This case can be regarded as a *general* case in which actors from different levels of government and various policy sectors collaborate with each other on transport issues in the Belgian federal state (Yin, 2009). There was another case that fitted the case selection requirements (i.e. multi-level and multi-sectorial actor involvement) – to mention: the transport of dangerous goods – yet, this case was considered to be too politically sensitive to investigate.

To disentangle the policy-level integration of the actors in the case of the EU ITS-directive, we look from a *political* and *managerial* perspective at the case. The political perspective views the nature of the eventual policy agreement between the different governmental levels (e.g. is it a holistic government strategy *or* rather a document in which all established regional and federal measures are mentioned without any policy-level integration between the levels of government?), and studies the nature of interaction (e.g. information exchange, arbitration, negative coordination, shared decision-making, etc.) between the actors involved in the deliberations on the transposal of the EU ITS-directive. The managerial dimension, in contrast, examines the decision-making structures that are in place, as well as, the type of instruments to monitor the transposal of the directive (e.g.: KPI's, accountability instruments, progress reports, planning tools, etc.). Together, these aspects must give us a gist of the extent to which political actors in the transposal of the EU ITS directive seek for policy-level integration in terms of decision-making as well as monitoring, accountability and supervision of the progress of the transposal. Insights on the degree of policy-level integration will be obtained through a series of interviews with stakeholders and a document analysis of relevant policy documents (policy plans, position papers, review reports, progress report, meeting reports, etc.).

With regard to the level of 'administrative integration' among the actors in the implementation of the policy actions of the EU ITS-directive, we use the research method of Social Network Analysis (SNA). SNA is a method designed for investigating social structures through the use of network and graph theories (Scott, 1991). It characterizes networked structures in terms of nodes (i.e. individual actors) and the ties (i.e. relationships) that connect them. Examples of social structures that are commonly visualized through SNAs include friendship networks, networks of disease transmission, social media networks, etc.

Data for the SNA is derived from the 2014 progress report that Belgium submitted to the European Commission to indicate what it has been doing to make the ITS a part of the larger EU transport system. The 2014-progress report offers a full oversight of the projects that have been set up as a follow-up of the 2010/40/EC directive. In total 81 projects are mentioned in the document. For each project it is indicated who the 'involved actors' (in the document labelled as 'lead stakeholders') were in the project. Based on this information, we code the 'nodes' (i.e. the governmental departments and agencies) for the analysis, and the 'ties' (i.e. the amount of projects that one *node* had in common with another *node*) that existed between these nodes. For the analysis, we use the UCINET software program. Eventually, the SNA will provide us with an overview of how the administrative actors organized themselves during the implementation of the ITS-directive – and what sorts of implementation clusters (and thus: *patterns of* administrative integration) are formed. See figure 1 for an output example of our SNA analysis.

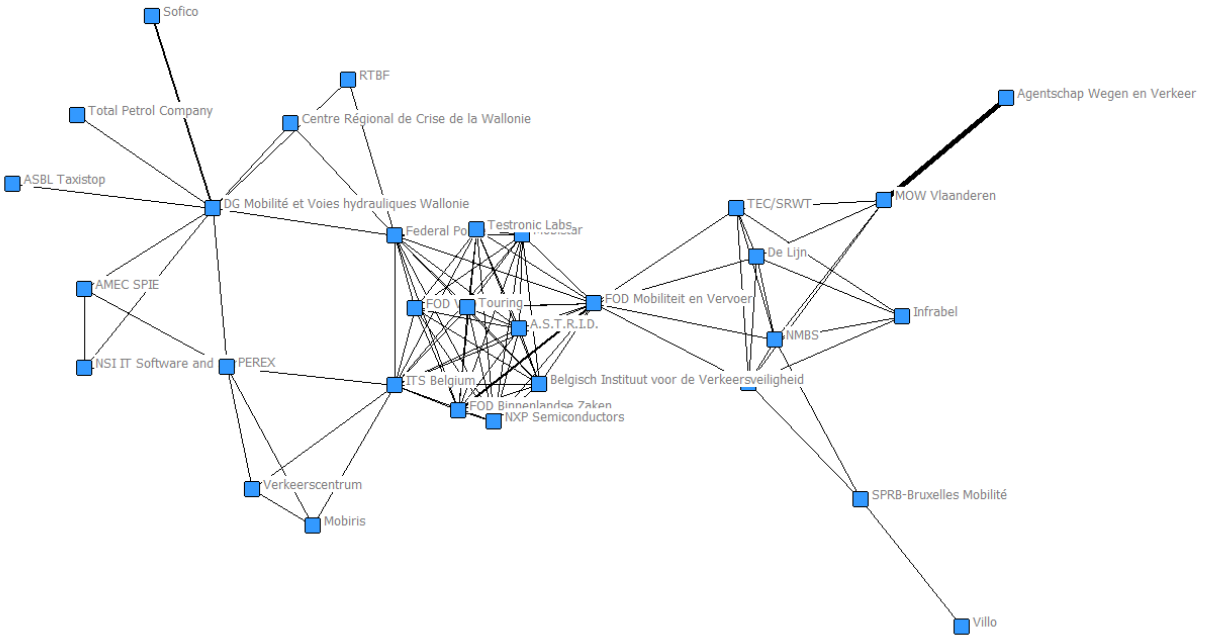

Figure 4: SNA analysis Belgian implementation ITS-directive.

2.2 Preferred levels of integration per scenario

In the previous section, we discussed the research strategy and methodology we will use to gain a notion of the current level of administrative and policy-level integration in the transport domain. Eventually, we compare these insights to those that emerge from the analyses about the preferred levels of integration for each of the future scenarios. In the next paragraphs, we discuss how we obtain the latter values.

To determine the preferred levels of integration per scenario, we build on various parameters that follow from the scenario analyses: (1) *the expected modal split in each scenario* and (2) *the changes in the scenario values of transport emissions, noise exposure, operational costs and energy consumption*. The modal split values reveal in which modality (i.e. inland waterways, road transport or rail transport) most change is expected in terms of the tkms that are transported by 2030. If we relate these *value changes* in modality to the competence division[3] among the actors involved in the transport domain, we get a sense of which responsible departments and agencies from the different levels of government *must be* involved in the transition in the transport domain to reach the set objectives with regard to the foreseen *modal changes* per scenario.

The second cluster of parameter values sets the ambition level of the foreseen intermodal (and sustainable) change – thus *the higher* the (positive) change in values regarding the transport emissions, noise exposure, operational costs and energy consumption, the higher the ambition level of the intermodal transition, and the more 'integrated' relevant political and administrative actors have to work together (in terms of creating greater coherence and avoiding policy differences, duplications and redundancy) to meet the set ambition level. Vice versa, if the ambition level is relatively low, there is less need for actors 'to get in the same boat and start rowing together'. Hence, the preferred level of administrative and policy-level integration per scenario will be

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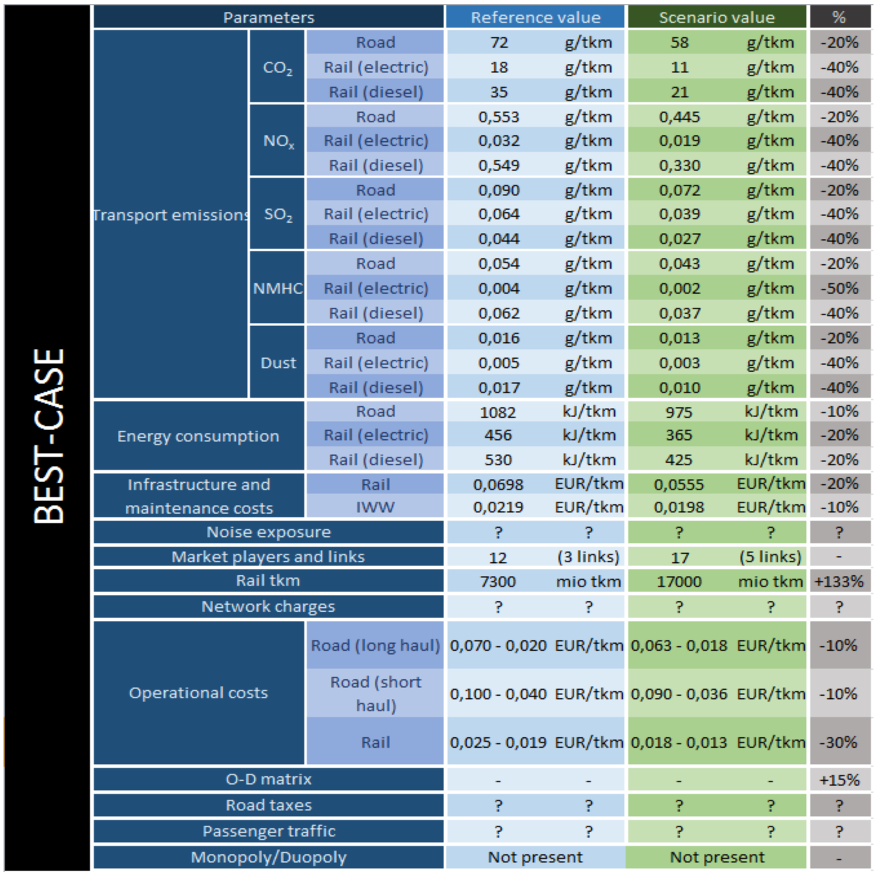
[3] Road transport is foremost regulated on the regional level, IWW is regulated at regional level and rail transport is regulated at federal level.

determined by examining *which actors have to be involved to enable the sustainable modal transition* and *how integrated their practices have to be in relation to the set ambition levels.*

From the scenario development document (WP1), the scenario and change values of transport emissions, noise exposure, operational costs and energy consumption are retrieved (Table 1, for example, amongst others shows the values of the 'best-case' scenario).



	Parameters			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	1082	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		Rail	0,0698	EUR/tkm	0,0555	EUR/tkm	-20%
			IWW	0,0219	EUR/tkm	0,0198	EUR/tkm	-10%
	Noise exposure			?	?	?	?	?
	Market players and links			12	(3 links)	17	(5 links)	-
	Rail tkm			7300	mio tkm	17000	mio tkm	+133%
	Network charges			?	?	?	?	?
	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%
	O-D matrix			-	-	-	-	+15%
	Road taxes			?	?	?	?	?
	Passenger traffic			?	?	?	?	?
	Monopoly/Duopoly			Not present		Not present		-

Table 2: Scenario values of 'best case' future situation.

However, in the future scenarios, the modal split values were not included. Instead, a rail-tkm parameter was defined, which had to be taken into account by all work packages. With the help of this rail-tkm parameter a calculation was made by the consortium partners to retrieve the expected modal split values per future scenario. These values and calculations were validated by the external stakeholder committee during the macro-economic workshop on the 14th of September, 2015 in Liège. The full calculation details can be obtained upon request. Table 2 presents the modal split values for each of the scenarios we use in this WP.

		Total transport	Road	Rail	IWW
REFERENCE	tkm	50,000	32,100	7,300	10,400
	modal split	100%	64%	15%	21%
BEST	tkm	85,000	47,000	17,000	21,000
	% rise in tkm	70%	46%	133%	102%
	absolute rise	35,000	14,900	9,700	10,600
	modal split	100%	55%	20%	25%
MEDIUM	tkm	71,500	41,500	12,000	18,000
	% rise in tkm	43%	29%	64%	73%
	absolute rise	21,500	9,400	4,700	7,600
	modal split	100%	58%	17%	25%
WORST	tkm	57,000	36,500	8,000	12,500
	% rise in tkm	14%	14%	10%	20%
	absolute rise	35,500	4,400	700	2,100
	modal split	100%	64%	14%	22%

2.3 Coordination toolbox for integration

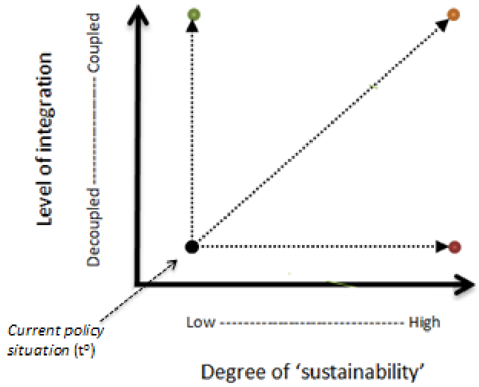


Figure 5: The levels of discrepancy between current levels of integration and preferred levels.

In the third and final part of the analysis, we bring the analyses of the first two parts together. Here we determine how much 'discrepancy' exists between the current policy situation (with regard to the levels of administrative and policy-level integration) and the preferred situations of the future scenarios (see figure 2). With 'discrepancy' we mean "the amount of *distance* that exists between the current level of integration among the political and administrative actors and the optimal or preferred levels of integration for each of the scenarios." Based on these discrepancy levels, we model the needed changes, capacities and instruments at the policy- and administrative level for managing the intermodal freight transport transition per future scenario.

Concretely, this means that, per scenario, we will come up with recommendations about the ways in which the multitude of organizations and their political leaders (and in particular those of the federal government) can coordinate and organize themselves in the (political) decision-making process and the (administrative) implementation process. We do so by relating the 'discrepancy levels' and required levels of integration to the existing scholarly literature on inter-organizational coordination (Bouckaert, Peters and Verhoest, 2010), pluricentric coordination in public governance (Pedersen, Sehested and Sørensen, 2011), meta-governance (Sørensen and Torfing, 2011), collaborative governance (Agranoff, 2006) and policy implementation (Van Meter and Van Horn, 1975) – and distil from these broad research branches lessons and best practices that can be applied to the Belgian transport domain regarding the intermodal transition.

Apart from the best practices and learning lessons of the existing body of literature, we devote in the final part of our research analysis specific attention to *inter-organizational learning practices* of actors in collaborations. There are two reasons for this: a theoretical and methodological approach. Theoretically, earlier research has indicated that 'learning' between (representatives of) organizations (i.e. the exchange of knowledge, information and ideas between actors) helps improve coordination (and integration), as actors get a better understanding of how others in the collaboration look at a certain problem situation. Further, this helps actors in collaboratio to develop creative and innovative policy solutions for cross-cutting policy problems. Methodologically speaking, however, existing research has mainly looked at learning practices among actors in collaboration as an emerging property of the collective, instead of a dyadic activity between two actors. As such, the literature has offered explanations of how (an absence of) learning in collaboration affects group-level outcomes and results (in terms of goal achievement, efficiency, etc.), but has failed in explaining why actors are more likely to learn from some actors in collaborations and not, or to a lesser extent, from others. Therefore, we believe it is important to take a closer look at the latter, as it will help us gain an understanding of the conditions under which actors are likely to engage in learning activities with each other, and hence can come to a shared policy solution or integrated implementation strategy. Consequently, these insights can add to our knowledge on how communication and learning among actors in collaboration can help coordination. Thus, these insights on learning can sharpen and strengthen the recommendations that we will draft. We will use the statistical network method of Exponential Random Graph Modelling to make inferences about the learning interactions between actors in collaboration (Robins et al., 2012). Currently, we are selecting relevant cases for this 'learning analysis'.

3. A GLIMPSE AT THE FINAL RESULTS

The first analyses indicate that, within the transport domain, involved governmental actors rather work within their organizational silos, instead of working across conventional organizational and governmental boundaries. From the scenario analyses, however, it becomes clear that for an intermodal transition, *more* administrative and policy-level integration is required in order to meet the set ambition levels. The extent to which 'more' integration is required differs per scenario. In the best case scenario, a highly-coupled administrative and policy-level integration is demanded, in the medium case scenario a loosely-coupled governance structure is required, while in the worst case scenario political actors together with their administrative organizations mainly continue to work within their own (policy) corners. Our recommendations will largely develop themselves throughout the project. As such, we will have by the end of the project a list of coordination mechanisms and instruments that can be implemented (by federal actors) in order to reach the envisioned levels of integration per scenario. Thus, throughout the three scenario's we will improve and further elaborate our generic recommendations about mechanisms and instruments, while adding for each scenario more detailed recommendations.

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