

Successful Development and Implementation of Transport Policy Innovations

Tackling Congestion on Port Hinterland Links

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Thesis submitted for the degree of
Doctor in Applied Economics
(*Doctor in de Toegepaste Economische Wetenschappen*)

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public defence: 27.06.2013

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List of abbreviations and acronyms

AAGR	average annual growth rate
AHP	analytic hierarchy process
AID	automatic incident detection
ATMS	active traffic management system
B/C	benefit/cost ratio
ratio	
CBA	cost-benefit analysis
CIS	Commonwealth of Independent States
DSRC	dedicated short-range communications
EC	European Commission
ECMT	European Conference of Ministers of Transport (currently: International Transport Forum)
EEA	European Economic Area
EEC	European Economic Community
EFTA	European Free Trade Association
EIB	European Investment Bank
EP	European Parliament
EU	European Union
GDP	gross domestic product
GPS	Global Positioning System
HGV	heavy goods vehicle
IPR	intellectual property rights
IRR	internal rate of return
IRU	International Road Transport Union
ITF	International Transport Forum
ITS	intelligent transport systems
IWW	inland waterways
NACE	Statistical Classification of Economic Activities in the European Community (in French: Nomenclature statistique des activités économiques dans la Communauté européenne)
NPV	net present value
NST	Standard Goods Nomenclature for Transport Statistics (in French: Nomenclature uniforme des marchandises pour les Statistiques de Transport)
NUTS	Nomenclature of Territorial Units (in French: Nomenclature des Unités Territoriales Statistiques)
OECD	Organisation for Economic Co-operation and Development
ROI	return on investment
SI	systems innovation
SSS	short sea shipping
TEN	Trans-European Networks
TEU	twenty-foot equivalent unit
UNIZO	Union of Self-Employed Entrepreneurs (in Dutch: de Unie van Zelfstandige Ondernemers)
VAB	Flemish Automobile Association (in Dutch: Vlaamse Automobilistenbond)
VAT	value added tax
VMS	variable message sign
VSL	variable speed limit

Summary

The pre-crisis traffic volumes at the seaports of Western Europe have demonstrated the unsustainability of port traffic turnover growth, often due to an important bottleneck: the hinterland connections of the ports. The governments are under pressure from industry to take actions, but are constrained by the limited availability of funding for road construction.

A good way of finding funding and solving congestion at the same time could be introduction of road pricing, but often in practice the introduction of such policy is not possible. There may be different reasons for this, including strong opposition from the road users that would have to pay, poor design of the pricing measure and bad management during the initiation stages of the project.

The goal of the doctoral research “*Successful Development and Implementation of Transport Policy Innovations: Tackling Congestion on Port Hinterland Links*” is to develop and validate an approach, which can be used to improve the success rate of such policy innovations. It should allow improving the design of policies by taking the implementation into account during the design stage of a policy.

To achieve this goal, a three-stage approach is followed in this research. First, an impacts simulation is done with the aim of determining the impacts of alternative scenarios tackling congestion on port hinterland links. This allows selecting a case study for further investigation. Then, having the results on the expected impacts of the measure, as the second step, social cost-benefit analysis of the innovation process with focus on the actors of the innovative process is performed. Last, the systems innovation approach is used for analysis of the innovation process and suggesting steps for assisting the market up-take of the innovation.

In the **first stage**, impacts simulation is done, because in practice the impacts of an innovative policy measure are hard to estimate for a concrete situation. The case-specific impacts simulation includes the following steps:

Step 1: qualitative analysis of port traffic evolution and impacting factors;

Here, in order to select and quantify variables for the Step 3 of the impact simulation the influencing factors for the case in focus are detected, because in every case those factors will differ and the impacts they have will differ as well.

Step 2: linking of selected influencing factors with the freight model used;

The previous step allows gaining general understanding of the influencing factors for the case study investigated. Here the selected influencing factors are linked with the variables that exist in the freight model.

Step 3: analysis using the freight model;

In the third step of impacts simulation the variables are fed into the freight model and the simulations are run.

Step 4: evaluation and selection of a case study.

In this step the interpretation and evaluation of the modeling results is done with the aim of selecting a suitable scenario for implementation, which will be investigated in the next stages of this research.

It is observed in the simulations that the impacts of a pricing measure on a road network are not homogenous. One scenario could have different or even adverse impacts at different locations of the road network. The simulation results show that sets of measures with similar consequences have greater effect. This is clearly demonstrated by scenarios 8, 11 and 12 where a set of combined policy measures is enacted. On the main port hinterland links, like the E313 motorway for the port of Antwerp, there are strong impacts of assumptions on port growth. The increased/decreased port throughput assumptions have an influence both on incoming and outgoing flows. These observations provide a deeper understanding of what the impacts of the concrete measure chosen would be on the concrete road network.

As a result of the first stage of investigation, a case study, which is likely to be considered by the government for practical implementation, is selected for further investigation. It deals with introduction of road pricing for heavy goods vehicles on Belgian motorway network. The price for using the motorway network for heavy goods vehicles is set to 0.15 €/km for the use of highways in Belgium and it replaces the circulation tax and Euro-vignette.

In the **second stage**, the cost-benefit analysis for the selected case study is done. The case study is treated as an innovation and broken down to cost components per actor. The benefits or revenues from an innovation are put on one side. On the other side, there are the private or social costs that are associated with implementation of the innovation. For an innovation to succeed, in general, the following relations should be true:

$$\begin{cases} \Delta R_p - \Delta C_p + S_p > x \\ \Delta B_s - \Delta C_s + S_s > y \end{cases}$$

where ΔR_p is the change in private revenues as a result of innovation, ΔC_p is the change in private costs as a result of innovation, and similarly, ΔB_s is the change in social benefit as a result of innovation, and ΔC_s is the change in social cost as a result of innovation. Subsidies which can be given to the different actors for supporting the innovation are S_p and S_s . Here x and y are threshold values that a private or public innovation actor requires in order to continue the innovation process, or to stop the innovation process.

Assigning the values to the variables allows seeing whether the success conditions are met and whether subsidies might be required for the success of the innovation. The analysis shows positive impacts of the project, which is an indicator for high likelihood for this innovation to succeed. But more importantly, it shows the costs and benefits for the involved actors. The analysis shows that most benefits, which come from time savings and reduction of externalities related to cargo traffic volumes, are enjoyed by individuals. For companies that are road users the benefits come from time savings and consumer surplus, but those do not outweigh the toll that has to be paid. This allows predicting which actor will be in favour and which against the innovation.

Last, as the **third stage**, the systems innovation (SI) approach for the analysis of the innovation is used. The reason for doing it is that it allows identifying the causes of success and failure of an innovation in the different temporal development phases of an innovation: initiation, development and implementation phase. It allows indicating which actions, when and where are required to establish the success conditions and the area where actions would not promote the success of the innovative process.

Here concrete actions are suggested for the government to alleviate the implementation process of the road pricing in Belgium. They describe what interactions with which actors should be encouraged. It can not be said that without following these developed suggestions the innovation would necessarily fail. But enacting these identified support measures should allow developing a more efficient implementation plan and avoiding certain problems that might occur in the innovation path.

The case analysed shows that the proposed methodological framework is applicable in practice. It also demonstrates the complexity that can be involved in such cases when it comes to real-life examples.

The political and practical dimension of the research results makes them relevant to governments and other innovators for applications in transport and other fields. The results of this research should contribute to the development of more efficient contemporary solutions for problems that transport policies are called to solve.

Samenvatting

De trafiekvolumes van voor de crisis de West-Europese zeehavens hebben aangetoond dat de omzetgroei van de haventrafiek onhoudbaar is, vaak als gevolg van een belangrijk knelpunt: de achterlandverbindingen van de havens. De overheden staan onder druk van de industrie om maatregelen te nemen, maar worden beperkt door de beperkte beschikbaarheid van financiering voor de aanleg van wegen.

Een goede manier om tegelijkertijd middelen te vinden en congestie op te lossen, zou de invoering van rekeningrijden kunnen zijn, maar in de praktijk is de invoering van dit beleid vaak onmogelijk. Hier kunnen verschillende redenen voor zijn, waaronder sterke tegenstand van de weggebruikers die zou moeten betalen, een slecht ontwerp van de prijszettingsmaatregel en slecht beheer tijdens de beginfase van het project.

Het doel van het doctoraal onderzoek "*Succesvolle ontwikkeling en implementatie van vervoerbeleidsinnovaties: aanpak van congestie op de hinterlandverbindingen van havens*" is het ontwikkelen en valideren van een aanpak die kan worden gebruikt om de slaagkans van dergelijke beleidsinnovaties te verbeteren. Het moet een verbetering van het beleidsontwerp mogelijk maken door tijdens de ontwerpfase van het beleid reeds rekening te houden met de implementatie ervan.

Om dit doel te bereiken, wordt in dit onderzoek een drie-fasige aanpak gevolgd. Eerst wordt een effectensimulatie uitgevoerd met als doel het bepalen van de effecten van alternatieve scenario's die congestie aanpakken op achterlandverbindingen van de havens. Dit laat toe een gevalstudie te selecteren voor verder onderzoek. Met de resultaten van de verwachte effecten van de maatregel, wordt als de tweede stap een maatschappelijke kosten-batenanalyse van het innovatieve proces uitgevoerd, met nadruk op de actoren van het innovatieve proces. Tenslotte wordt de systeeminnovatiebenadering gebruikt om het innovatieproces te analyseren en om maatregelen te suggereren om de marktopname van de innovatie te ondersteunen.

In de **eerste fase** wordt de effectensimulatie uitgevoerd, omdat de effecten van een innovatieve beleidsmaatregel in de praktijk moeilijk in te schatten zijn voor een concrete situatie. De geval-specifieke effectensimulatie omvat de volgende stappen:

Stap 1: kwalitatieve analyse van de evolutie van de haventrafieken effectfactoren;

Om variabelen voor stap 3 van de effectensimulatie te selecteren en te kwantificeren, worden hier de beïnvloedende factoren voor het betrokken geval gedetecteerd, omdat deze factoren, alsook hun effecten, voor elk afzonderlijk geval zullen verschillen.

Stap 2: koppeling van geselecteerde beïnvloedende factoren met het gebruikte vrachtmodel;

De vorige stap laat toe om algemene kennis te verwerven over de beïnvloedende factoren voor de onderzochte gevalstudie. Hier zijn de geselecteerde beïnvloedende factoren gekoppeld aan de variabelen die bestaan in het vrachtmodel.

Stap 3: analyse aan de hand van het vrachtmodel;

In de derde stap van de effectensimulatie worden de variabelen ingevoerd in het vrachtmodel en worden de simulaties uitgevoerd.

Stap 4: evaluatie en selectie van een gevalstudie.

In deze stap gebeurt de interpretatie en evaluatie van de modelresultaten met als doel het selecteren van een geschikt scenario voor de implementatie, wat wordt onderzocht in de volgende fasen van dit onderzoek.

In de simulaties blijkt dat de effecten van een prijszettingsmaatregel op een wegennet niet homogeen zijn. Een scenario kan verschillende of zelfs ongewenste effecten hebben op verschillende locaties van het wegennet. De simulatieresultaten tonen dat de reeksen maatregelen met vergelijkbare gevolgen meer effect hebben. Dit wordt duidelijk aangetoond door scenario's 8, 11 en 12, waar een reeks gecombineerde beleidsmaatregelen wordt vastgesteld. Op de belangrijkste achterlandverbindingen van de haven, zoals de E313 autosnelweg voor de haven van Antwerpen, zijn er sterke effecten van assumpties over havengroei. De verhoogde / verlaagde veronderstellingen over de haventrafiek hebben invloed op zowel inkomende als uitgaande stromen. Deze waarnemingen geven een dieper inzicht in wat de effecten van de concrete gekozen maatregel zou zijn op het betrokken wegennet.

Als gevolg van de eerste fase van het onderzoek is een gevalstudie, die waarschijnlijk door de overheid zou worden overwogen voor de praktische uitvoering, geselecteerd voor verder onderzoek. Het gaat over de invoering van rekeningrijden voor zware vrachtwagens op het Belgische autosnelwegennet. De prijs voor het gebruik van het wegennet is voor zware vrachtwagens ingesteld op 0,15 € / km voor het gebruik van snelwegen in België en het vervangt de verkeersbelasting en het Eurovignet.

In de **tweede fase** wordt de kosten-batenanalyse voor de geselecteerde gevalstudie uitgevoerd. De gevalstudie wordt behandeld als een innovatie en wordt ontbonden tot kostencomponenten per actor. Enerzijds zijn er voordelen of opbrengsten uit een innovatie. Anderzijds zijn er private of maatschappelijke kosten die worden geassocieerd met de implementatie van de innovatie. Opdat een innovatie kan slagen, moeten in het algemeen aan volgende relaties voldaan zijn:

$$\begin{cases} \Delta R_p - \Delta C_p + S_p > x \\ \Delta B_s - \Delta C_s + S_s > y \end{cases}$$

waar ΔR_p de verandering is in private opbrengsten als gevolg van de innovatie, ΔC_p de verandering in private-kosten als gevolg van de innovatie, en zo ook ΔB_s de verandering in maatschappelijke baten als gevolg van de innovatie, en ΔC_s de verandering in de maatschappelijke kosten als gevolg van de innovatie. Subsidies die aan de verschillende actoren kunnen worden gegeven ter ondersteuning van de innovatie, zijn S_p en S_s . Hierbij zijn x en y drempelwaarden die een publieke of private innovatie-actor nodig heeft om het innovatieproces verder te zetten of om het innovatieproces te stoppen.

Het toewijzen van de waarden aan de variabelen maakt het mogelijk om te zien of aan de succesvoorwaarden is voldaan en of subsidies nodig zijn voor het succes van de innovatie. De analyse toont positieve effecten van het project, wat een indicator is voor een hoge slaagkans voor deze innovatie. Maar nog belangrijker is dat het de kosten en baten voor de betrokken actoren weergeeft. De analyse toont aan dat het individuen zijn die de meeste voordelen genieten die voortkomen uit tijdwinst en verminderde externe effecten gerelateerd aan vrachtverkeer. Voor bedrijven die wegvervoer gebruiken, komen de voordelen voort uit tijdwinst en consumentensurplus, maar deze voordelen wegen niet op tegen de tol die betaald

moet worden. Hierdoor kan voorspeld worden welke actor voor en welke tegen de innovatie zal zijn.

Tot slot, als **derde fase** wordt de systeeminnovatie(SI)-benadering gebruikt voor de analyse van de innovatie. De reden hiervoor is dat dit mogelijk maakt om de oorzaken van succes en falen van een innovatie te identificeren in de verschillende tijdelijke ontwikkelingsfasen van een innovatie: begin-, ontwikkelings- en implementatiefase. Het maakt het mogelijk om aan te geven welke acties wanneer en waar nodig zijn om de succesvoorwaarden alsook het gebied waar maatregelen niet bevorderlijk zouden zijn voor het succes van het innovatieve proces, vast te stellen.

Hier worden concrete acties voorgesteld om het implementatieproces van rekeningrijden in België te verlichten voor de overheid. Deze beschrijven welke interacties met welke actoren moeten worden aangemoedigd. Het kan niet worden gezegd dat de innovatie zonder het volgen van deze ontwikkelde suggesties per se zou mislukken. Maar het aannemen van deze vastgestelde ondersteunende maatregelen moet de ontwikkeling van een efficiënter implementatieplan en het vermijden van bepaalde problemen die zich kunnen voordoen in het innovatietraject, mogelijk maken.

De geanalyseerde gevalstudie toont dat het voorgestelde methodologisch kader toepasbaar is in de praktijk. Het toont ook de complexiteit aan die met dergelijke gevalstudies gepaard kan gaan als het gaat om voorbeelden uit de realiteit.

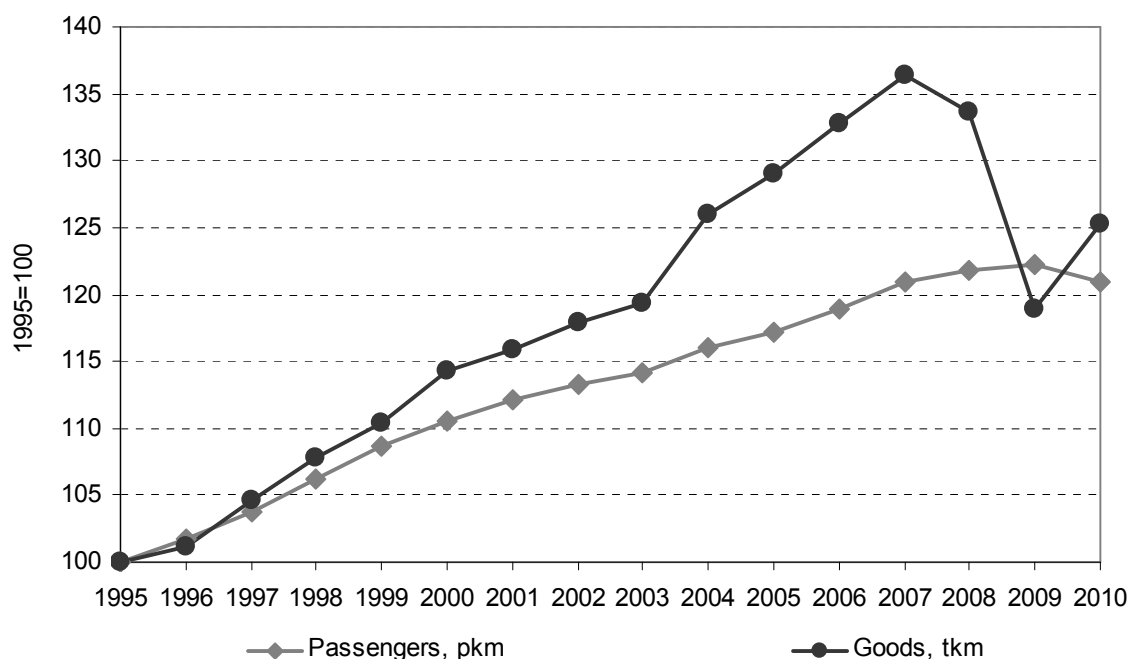
De politieke en praktische dimensie van de onderzoeksresultaten maakt deze relevant voor overheden en andere vernieuwers van toepassingen in de transportsector en andere domeinen. De resultaten van dit onderzoek moeten bijdragen tot de ontwikkeling van efficiëntere eigentijdse oplossingen voor problemen die het vervoerbeleid moet oplossen.

CHAPTER 1 Introduction

1.1 Setting

In the last decades, Europe has faced rapid increases in transport volumes and road transport volumes in particular. The statistics of passenger and goods transport of recent years (see Figure 1) show a steady increase for over a decade with a decrease in 2008 and 2009 due to the economic crisis.

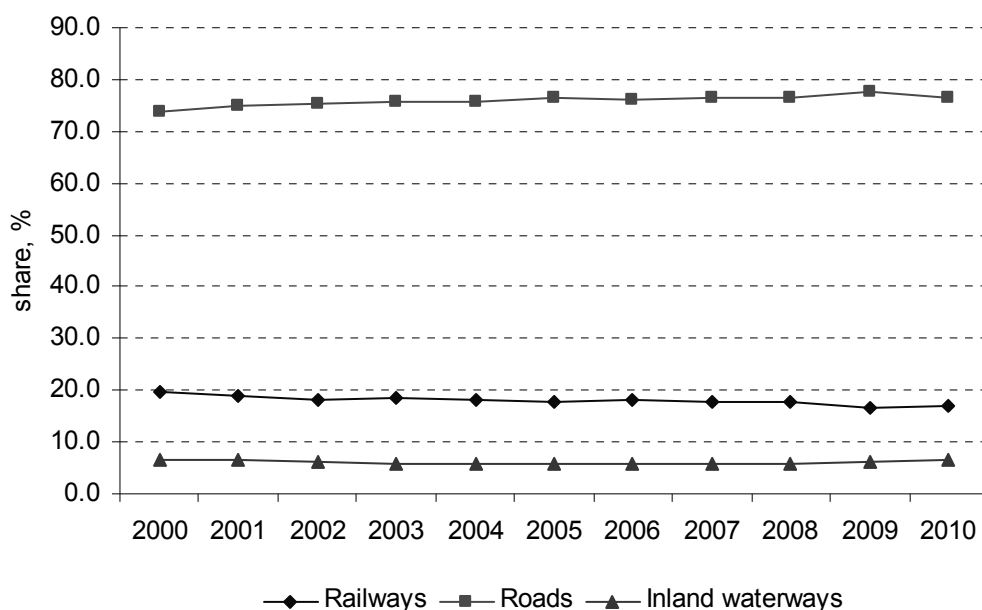
Figure 1: Transport Growth EU 27: Passengers, Goods



Source: European Commission (2012b)

In the goods traffic modal split the share of road transport in the EU27 has stayed around 75% and the so called “alternative modes” of transport have not managed to increase their share despite the political support at different government levels (see Figure 2).

Figure 2: Freight Transport Modal Split EU 27, 2000-2010



Data source: European Commission (2012a)

Limited availability of funds and space for road construction in conjunction with the increasing traffic volumes leads to occurrence of congestion on the road networks of most European countries. A good way of finding funding and solving congestion could be pricing.

In this situation of increasing traffic and limited availability of funding society still expects actions to be taken by the government. The government has different tools that it can enact to respond. Measures to reach mode shift of freight traffic away from road to other modes for freight transport are generally considered to free up road space for passenger car users.

In practice, however, the introduction of such measures for tackling congestion is not always successful. There may be different reasons for that, including strong opposition from the road users, poor design of the measure or bad management during the initiation.

The situation of increasing traffic levels, lack of road space and pressure on government to act from the public side clearly asks for development of appropriate public actions in the situation of lack of financing, which is common in most of the countries. Searching for a way to efficiently develop these actions and make them implementable is the reason for writing this thesis.

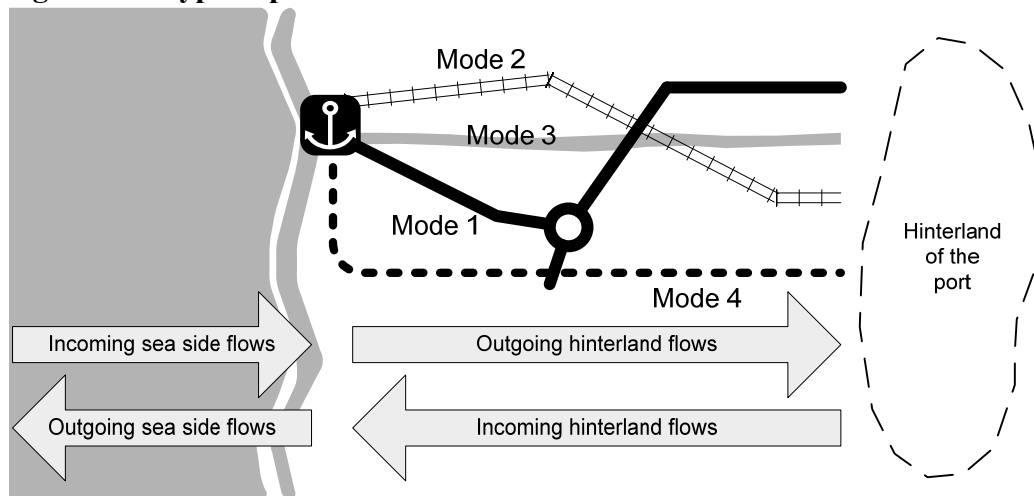
1.2 The situation in focus

The research in this thesis deals with a typical port hinterland situation shown in Figure 3. It features a port which has incoming and outgoing cargo flows on the seaside and, similarly, incoming and outgoing cargo traffic flows on the land side. On the sea side the incoming and outgoing cargo is transported to and from other ports by sea. On the land side alternative modes of transportation exist. In the simplified model in Figure 3 a choice between four alternative modes of transport exists:

- mode 1 – road transport;
- mode 2 – rail transport;
- mode 3 – inland waterway transport;
- mode 4 – pipeline transport.

In practice the number of hinterland modes can vary. A port can have just one hinterland transport mode, or it can have all four, or more. Also, one of the modes is often dominant and carries a big share of the hinterland traffic. Some types of cargo are more suitable for one mode, but can not be transported by another mode. For example, containerised goods can not be transported in classical pipelines. More often than not the dominant role in the hinterland transport is played by road transport.

Figure 3: A typical port hinterland situation



Competition for space exists on all hinterland modes. On the port hinterland links, freight traffic competes for the use of infrastructure with other users. On inland waterways, barges share the capacity with recreational vessels; on rail, cargo trains share slots with passenger trains; and on the road, trucks share the road infrastructure with passenger cars and other vehicles. This research focuses only on measures that are applicable to freight traffic on these hinterland links of the ports.

These applicable measures include different pricing measures, regulatory measures and infrastructure measures that could be applied. The pricing measures could be different variations of pricing schemes. In each situation with its geographical and cargo traffic characteristics, a different pricing scheme would be optimal. Regulatory measures are rules or laws put in place by the government that set the specifications or performance characteristics of transport operations. Infrastructure measures are related to construction of new or making changes to the existing infrastructure.

The measures targeted at passenger traffic are not investigated in this research.

1.3 Traditional approaches

Traditional approaches to tackling the problem of increasing traffic levels and lack of road capacity include road pricing, regulatory and infrastructure measures.

1.3.1 Road pricing literature

Pigou (1920) suggested tolls on public roads to tackle congestion. In his book “The Economics of Welfare” he developed Alfred Marshall’s concept of externalities, costs imposed on others that are not taken into account by the person taking the action.

Walters (1961) discussed the applicability of marginal cost (first-best) pricing on the highways to deal with peak-load problems. Based on empirical evidence he proposed the use of gasoline taxes and special tolls in congested areas. Mohring and Harwitz (1962) were the first to show that optimal pricing and investment decision for highways can be dealt with analytically in a single model.

Marginal cost pricing is the first-best pricing where congestion is the only externality. When road usage is linked with other externalities in practice according to Diamond and Mirrlees (1971) second-best theory should be applied.

Second-best pricing got ample attention in the literature in the 1990s, because, according to Verhoef (2002), first-best pricing for a congested road network is a rather theoretical concept. In practice often only second-best solutions are considered. Examples of second-best pricing include pay-lanes, toll cordons, parking charges, area permits and others.

Road pricing implementation cases can be seen around the world. Currently available technologies for implementation are listed and described in de Palma and Lindsey (2009).

1.3.2 Regulatory measures

Regulatory measures are legal restrictions or rules for action set by a government authority in order to induce actions which would otherwise not occur. A full list of all EU transport legislation acts is available from the website of the International Transport Forum (2010). Local country, region or city specific measures also apply.

1.3.3 Infrastructure measures

Expansion of existing road capacity has been the traditional response to growing congestion. It is also often considered an important determinant of economic growth and means of lowering social inequality, see Lopez (2003), Kerali (2003) and Calderon and Serven (2005). Of course, constraints that construction of new roads can face should be taken into account. Those include but are not limited to shortage of public funds, space and environmental issues.

1.4 The problem

With the increased port traffic turnover growth the goods traffic flow on the dominant hinterland transport mode increases and leads to congestion at certain times of the day. This is a common phenomenon which can be observed on the hinterland connections of many ports, usually on the road networks.

In the context of freight traffic, congestion results in increased costs related to time, uncertainty about arrival times, waste of fuel, increased wear of vehicles and other negative effects, including those on the environment. Also, increased levels of congestion on the land side negatively affect the competitive position of ports.

In the literature (see CHAPTER 2, Table 3 on page 24 for summary) a range of applicable measures for tackling the congestion problems is available. Those include different marginal cost, second best, facility-based, distance-based pricing and zonal pricing schemes. Also, possible impacts of these measures are known from the literature and there are certain preconditions for implementation of each of these measures. Creating or suggesting new measures is outside the scope of this research.

The efficiency of the available capacity optimization measures is evident, but the problem is that the implementation almost always faces strong opposition from the public or some interest groups. Therefore in this research the implementation process of these measures is investigated with the aim of identifying certain conditions under which there is a high chance of successful implementation. This would allow the policy measures to be designed with implementation in mind.

When developing the applicable measures for reducing congestion, the impacts for the individual actors in the society are usually not taken into account. Most of those measures that could be implemented for tackling congestion are “painful” to one or another actor. That causes problems in practical implementation. And if those measures for tackling congestion do get implemented, the design of the measure is often impacted by those affected actors, which can decrease the efficiency of the measure.

The problem is that the traditional approaches do not tackle the practical implementation path of those policy measures. Therefore, an approach which takes the implementation path and the involved actors into account is needed.

This research is relevant, because literature sources on pricing measures do not target the practical implementation of these measures. But practical implementation is important for any result to be achieved at all. This research, therefore, bridges this gap between the literature which develops possible infrastructure use optimization measures and literature which analyses the success conditions of innovations.

1.5 Search for a solution

A lot of inspiration for this doctoral research has come from research projects that the author of this thesis has worked on. Those projects include “Tactical study E313 – calculating future scenarios for freight transport” which researched possible measures for an improved traffic on the E313 motorway, “InnoSuTra - Innovation processes in surface transport” which dealt with innovation in transport and logistics chains, “Market-up” which aimed to identify barriers and drivers for the market uptake of transport research and other smaller projects. As a result, throughout the text it is referred repeatedly to results from these research projects.

Also, several literature sources have contributed as an inspiration in search for the solution to the problem defined for this research.

The traditional approaches (described in 1.3 above) provide a source of inspiration when designing a measure that would be applied for tackling the congestion. But since they do not deal with the implementation path of those measures, one has to look elsewhere.

Literature that focuses on the implementation processes of innovations exists. It provides a framework for research on what happens to innovations from the moment of initiation till the real-life implementation. Such innovation process theory is developed by Van de Ven *et al.* (1999). The Organisation for Economic Co-operation and Development and Statistical Office of the European Communities (2005) has developed the Oslo Manual as a method for measuring innovative activities. It includes guidelines for collecting and interpreting innovation data. The Systems Innovation approach developed by Woolthuis *et al.* (2005) focuses on the interactive mechanisms that shape the emergence and diffusion of innovations. It allows determining the chances of the innovation to be successfully implemented.

Current literature fails to apply the available measures for dealing with congestion in conjunction with the knowledge that exists on the implementation of innovations. There is room for synergies, because the implementation path of an innovation is the key to its success.

An integrated approach would allow, first to identify where the conditions for successful innovation are not met, and then to identify the key innovation variables to be addressed with which the actors may best be stimulated by policy intervention to ensure that the appropriate success conditions can be met, allowing successful implementation of the measure tackling congestion.

This doctoral research tries to solve the problem (defined in subchapter 1.4) by proposing an approach that allows developing appropriate measures and ensuring their successful implementation.

1.6 Research objective

The main objective of this research is to develop and validate an approach, which can be used to improve the success rate of transport-related policy innovations. It should allow proposing better policies by taking the whole innovation path of the policy into account during its design.

The developed approach should be applicable in practice for the development of policy innovations on local, regional, national and supranational level. The validation uses a real-life case study for a policy which is currently under consideration.

1.7 Propositions

For the purpose of conducting the research the following propositions for the thesis are formulated.

P1: Implementation of a transport policy measure to tackle congestion problems requires tailoring a custom solution, which includes a measure or a set of measures, for a particular implementation situation.

P2: Conditions that determine successful implementation of innovative concepts, like measures for tackling congestion on port hinterland links, exist and can be identified.

P3: Pricing measures are efficient and can be applied for decreasing freight traffic intensity on road networks in port hinterland situations where alternative transport modes exist. They reduce demand and promote mode shift.

P4: In port hinterland situations implementation of transport policy measures (including different pricing instruments) with similar consequences reinforce each other. Those synergies can be exploited by developing complex sets of policy measures for practical implementation.

P5: The proposed methodological framework (developed in CHAPTER 3) is applicable for testing the success or failure of innovations. It allows developing innovations that are easier to implement and producing practical suggestions for optimising innovation path of innovation cases in practice.

The propositions are tested along the research path as shown in Figure 4.

1.8 Approaches taken

The methodology used consists of several building blocks which are applied to develop the systematic approach used for the doctoral research. The scope of application of these blocks is described further in this section.

1.8.1 Literature review

The literature review done is described in CHAPTER 2. The literature review focuses on (1) the innovative process, (2) the applicable measures for infrastructure use optimization, and (3) the influencing factors that are present in the case study that is chosen for analysis. The results of the literature review serve as inputs for the other parts of the research.

The literature review on innovative process defines innovation and sets out typology and describes the innovation process. The purpose of section 2.1 is not to give a comprehensive overview of the innovation literature, but to present the reader with concepts that are referred to during the research.

The literature review of applicable measures gives a comprehensive overview of the applicable measures. It summarizes the impacts of the measures described in the literature and lists the impacts of these measures. Also, the conditions that are needed to achieve those impacts are summarised for each of the measures.

For the influencing factors that are present in the case study, only the most important for the particular case study have been chosen, but that does not exclude the existence of other factors. In a different situation, for a different case study, other factors might appear to be more important and their impacts should be considered then.

1.8.2 Simulation of impacts of measures

For simulation of the impacts of possible pricing measures, an existing Freight model Flanders is chosen. The model choice was determined by the case that is investigated in this research. In theory, a model could have been constructed for the purpose, but the chosen

model provides far better outputs than a model developed in the PhD research could. The purpose of this research is not to create the model, but to use modeling as a tool for determining the impacts of the policy measure investigated.

The Freight model Flanders is a model commissioned by the Flemish Traffic Centre and it has been developed by K+P Transport Consultants, Tritel and Mint¹. It is a classical 4-step model which allows simulating future freight flows, split up by mode (road, rail and inland waterways) and NST² freight category.

The main advantage of using a model for the purpose is that a quantified estimation of the impacts of a policy measure can be obtained based on the change in transport costs. The quantified outputs of the model can then be used in the cost-benefit analysis. A disadvantage, however, is that only the impact of relatively small cost changes can be tested.

1.8.3 Cost-benefit analysis

There are two ways to tackle the problem defined in section 1.4. The first is using social cost-benefit approach, the second is using innovation analysis (described below in 1.8.4). Those are not meant to replace, but to complement each other. In this, the richness of the selected methodological solution appears.

The cost-benefit analysis is a process of calculating and comparing costs and benefits of a proposed project. Money is a good way of comparing dissimilar things. The social cost-benefit analysis can be applied if the quantification of the costs and benefits of the project is possible. In this research the social cost-benefit analysis is performed. In a real-world pre-implementation situation, possibly in the development stage of an innovation, the cost structure would have more sub-elements than in this research. This is because the technical characteristics and exact costs of the equipment used would be known and could be included. But it would still include the same main cost and benefit components as in this approach.

1.8.4 Innovation analysis

The Systems Innovation (SI) approach allows taking the practical implementation of the policy measure into account when developing it. It includes taking into account the actual impacts on the infrastructure users, the technical design of the system and also the system control and functioning algorithms; basically, taking into account the innovation path of the policy measure.

When talking about innovation a definition should be given, because the term is often misunderstood. In this research the definition of Peter Drucker from Hesselbein *et al.* (2002) is used: “*Innovation is change that creates a new dimension of performance*”.

It is important to distinguish between innovation and invention. An invention does not become an innovation until it has gone through the stages of development and can be introduced (see section 2.1.3 on page 14). Invention is often not ready for practical implementation.

¹ Version used in this research.

² EC regulation 1304/2007 establishes NST 2007 as classification for goods carried in road freight transport.

In this research the inventions are not investigated. Also, there is no intention to come up with any invention. The analysis of innovative processes is done instead.

As inputs for the SI analysis, successful (see Table 1) and unsuccessful (see Table 2) innovation cases are used. In this research, the detailed analysis of the cases is done for the four road cases. Additional 13 cases were analysed in the InnoSuTra project³, using the same SI analysis methodology.

Table 1: InnoSuTra success cases analysed

	Road	Rail	Maritime	IWW	Intermodal
Technological	Variable Speed Limits		Reefer containerisation	Information Technology in the inland navigation industry	Port Community System
					Superfast Ferries
Organizational		Eurotunnel			Freight Villages
Policy	EU Cabotage		Port State Control		

Source: Arduino *et al.* (2011a)

Table 2: InnoSuTra no-success cases analysed

	Road	Rail	Maritime	IWW	Intermodal
Technological			Cold ironing	Air lubrication of ships	
Organizational			Indented berth	Available capacity on small inland waterways	
Policy	Eurovignette Directive				Internalization of external costs
	Introduction of three loaded trips limit in ECMT multilateral road transport permit system				European Intermodal Loading Unit

Source: Arduino *et al.* (2011a)

Both, the SI and cost-benefit analyses, are applied to the case study of a pricing scenario on the Belgian road network further in this thesis.

In general, the research results are limited by the methodology used and the scope of the research. The outputs do not deal with psychological aspects that are associated with the implementation of infrastructure optimization measures. It is also assumed that the decisions of the decision makers are rational and that the axioms of economics are true.

The existence of various indirect impacts that introduction of an innovation brings is acknowledged. For example, an indirect impact of introduction of road pricing in the

³ An EU FP7-financed project in which the author of this thesis participated. <http://www.innosutra.eu>

hinterland of a port could be reduction of competitiveness of that port. Evaluation of such indirect impacts is not done in this research.

Also, the technical aspects of the implementation are not dealt with. But if a new technology appeared and it was applied, the approach taken in this research and the results obtained should still be valid.

1.9 Outline

The organization of this dissertation is shown in Figure 4. The present chapter is an introductory chapter. It is written with the purpose of describing the setting, defining propositions and outlining research objectives for this PhD thesis. It also defines the scope of the research.

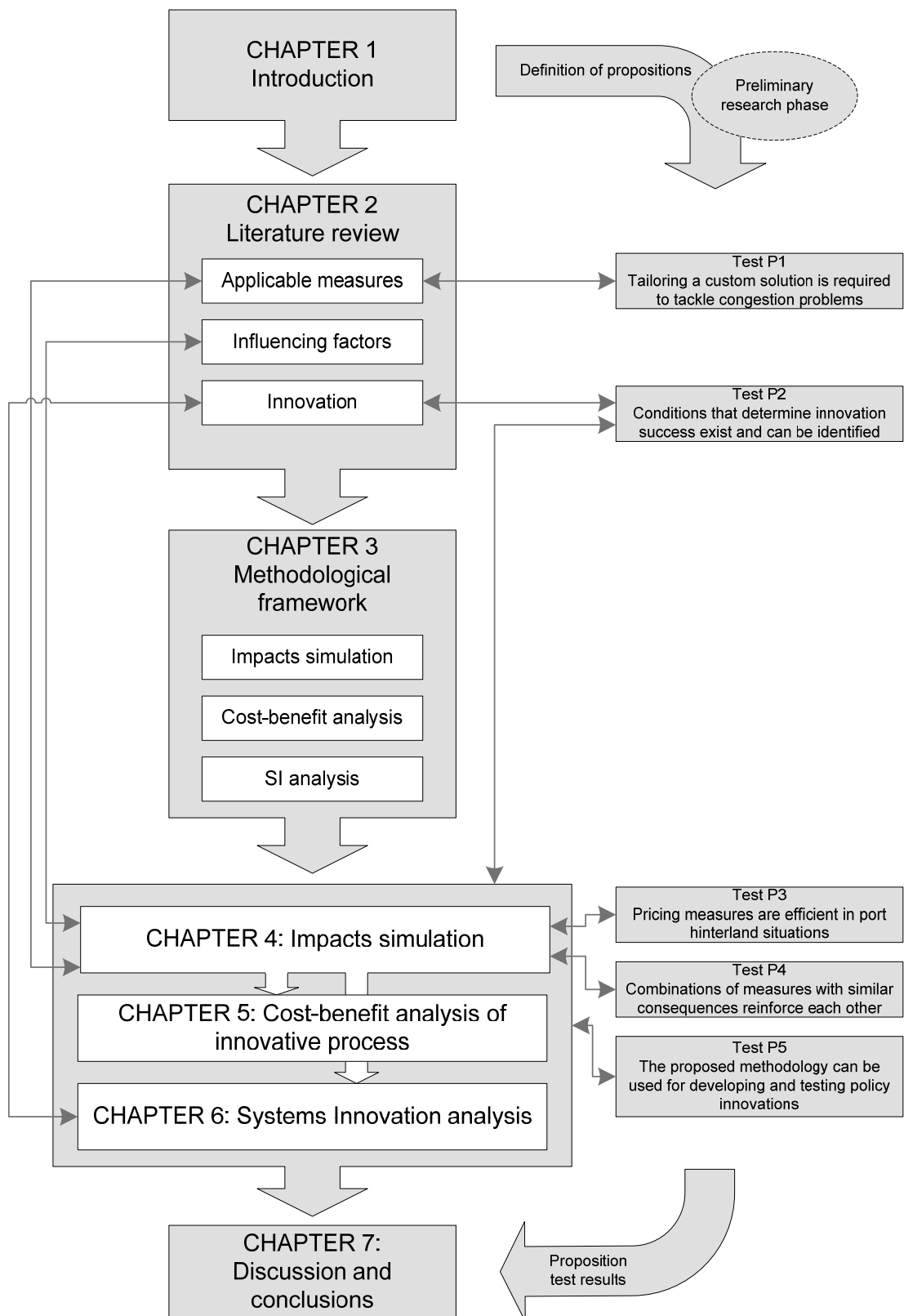
CHAPTER 2 presents the literature review defining the innovation and covering the framework for analysing an innovation process. Also, possible measures that can be introduced for alleviating congestion on road networks are covered. The literature review includes a summary of applicable measures which describes the impacts of these measures, and also lists the conditions/inputs needed and aspects to consider in the practical implementation. The impacts of other influencing factors to be considered according to empirical evidence are also covered.

CHAPTER 3 develops the methodological framework of the thesis and the following three chapters present the analysis performed in line with the developed methodology. In the first stage of the application, in CHAPTER 4, since the outcomes of a measure applied differ in each situation, these outcomes are modelled to determine the results for the concrete situation in focus. In the second stage, in CHAPTER 5, the cost-benefit analysis of an innovation process is used. This allows determining the outcomes of the innovation process and evaluating its success. Last, as the third stage in CHAPTER 6, to further contribute to the results of the cost-benefit approach, the Systems Innovation (SI) methodology is used.

CHAPTER 7 discusses the most important findings of the study in a structured manner. The implications of the research results at scientific, political and practical level are discussed and the conclusions are drawn in section 7.4.

The propositions are tested along the research path in the corresponding chapters as shown in Figure 4.

Figure 4: Logical relationships of chapters of the thesis



CHAPTER 2 Literature review

The literature review is developed with three goals in mind. The first goal of the literature review is to obtain a definition of the innovation, because it is one of the main concepts that are used throughout the thesis. This should allow gaining a general understanding of what an innovation is, what the innovation development process is like, and what interactions can exist in the process. As a result, this should provide an input for the development of the methodology, showing a way how the success of the innovation could be searched for.

The second goal when developing the literature review relates to the problem of congested port hinterland links. The goal is to investigate the applicable measures for tackling congestion in different situations according to literature. This would provide inputs for development of the measure for dealing with the concrete situation that is investigated as the case study in this thesis.

Acknowledging the existence of other influencing factors external to the innovation itself, the third goal of the literature review is to investigate and evaluate these influences. This should be done with a focus on the port hinterland situation and the case study that this thesis investigates. This should provide inputs for the model-based analysis in the later stages of the research.

Therefore, this chapter consists of four sections. Section 2.1 defines the term innovation and describes the characteristics of an innovation process. Section 2.2 presents the available applicable measures that can be introduced for alleviating congestion on road networks. It also includes a table that summarizes the impacts of these measures, and also lists the conditions/inputs needed and aspects to consider in practical implementation.

As the empirical evidence shows, the dynamics of port turnover influence the cargo flows on the road network substantially. Therefore section 2.3 presents a literature review on port choice by shipping lines and other actors as influencing congestion on port hinterland links.

Section 2.4 summarizes the conclusions from the literature review on the innovation process and applicable measures.

2.1 Innovation

In this section, after defining the innovation in detail, the characteristics of an innovation are defined from the economic point of view to be used for developing the methodology of this thesis.

2.1.1 Definition

In innovation literature there is lack of consensus in defining innovation. A general definition found in literature is the following:

Innovation is change that creates a new dimension of performance. (Peter Drucker in Hesselbein et al. (2002))

A study of OECD (1991) defines innovation from an overall perspective:

Innovation is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention.

A more elaborated definition of innovation applied to transportation and logistics comes from the InnoSuTra project, Arduino *et al.* (2010a):

A technological or organisational (including cultural and marketing as separate subsets) change to the product (or service) or production process that either lowers the cost of product (or service) or production process or increases the quality of the product (or service) to the consumer.

It must be stressed, especially in the context of this research, that an innovation can culminate in either:

- the introduction or a change of a product;
- the introduction or a change of a process.

2.1.2 Types of innovations

All innovations are not the same, therefore different sources present different typologies for innovations. A review of literature by Garcia and Calantone (2002) gives a good overview and reveals several categorizations from different sources (see Annex 2). Those typologies are often overlapping and the same term in different typologies can mean something different.

For the purpose of this research the innovations are grouped based on the type of change or innovation they introduce⁴:

1. Purely Technology Innovation;
2. Managerial, Organisational & Cultural Innovation, and
3. Technology, Managerial, Organisational, Cultural Innovation.

2.1.3 Policy innovation

The literature on policy innovation defines innovation as “as a program or policy which is new to the states adopting it, no matter how old the program may be or how many other states may have adopted it”, Walker (1969).

Shipan and Volden (2008) investigate the patterns of diffusion of policy innovations using data on antismoking policy choices of US cities. They conclude that the most appropriate policy for one government may be different from that for another government serving a different population.

Walker (2006), using data from five innovation cases, presents a statistical examination of innovation type and its diffusion across English local governments. He concludes that a variety of factors drive the diffusion of innovation in public organizations. Policymakers, if

⁴ Based on Arduino *et al.* (2011b).

seeking to encourage public organizations to innovate, need complex policy tools that ensure that appropriate determinants of innovation adoption are in place.

Mintrom (1997) focuses on the role of actors during a policy innovation process. He finds that policy entrepreneurs, political actors who promote the introduction of policy innovations, raise significantly the rate of legislative consideration and approval.

2.1.4 Stages of the innovation process

The innovation process is characterised by several stages. Those stages do not necessarily occur in a linear process. They can contain loops and overlap with each other. In a longitudinal study by Van de Ven *et al.* (1999) these stages are observed in most of the innovation processes. Because every innovation process is different, some steps may be missing in a particular case. Or some additional steps may be present.

Common stages of the innovation process according to Van de Ven *et al.* (1999) are:

2.1.4.1 Initiation period

- An extended gestation period lasting for several years in which seemingly coincidental events occurred that preceded and set the stage for the initiation of innovation.
- Concentrated efforts to initiate innovations are triggered by “shocks” from sources internal or external to the organization.
- Plans are developed and submitted to resource controllers to obtain the resources needed to launch innovation development.

2.1.4.2 Development period

- Initial innovative ideas proliferate into numerous ideas and activities.
- Setbacks and mistakes are frequently encountered.
- Criteria of success and failure often change, differ between resource controllers and innovation managers and diverge over time, often triggering power struggles between in- and outsiders.
- Innovation personnel participates in highly fluid ways. Personnel participates in part time jobs and has high turnover rates. High turn-over rates frequently occur due to emotions during the innovation process (euphoria in the beginning, frustration in the middle and closure in the end).
- Investors and top-managers are frequently involved in the development process.
- Innovation development entails developing relationships with other organizations.
- Innovation participants are involved with competitors, trade associations, and government agencies to create an industry or community infrastructure to support the development and implementation of their innovations.

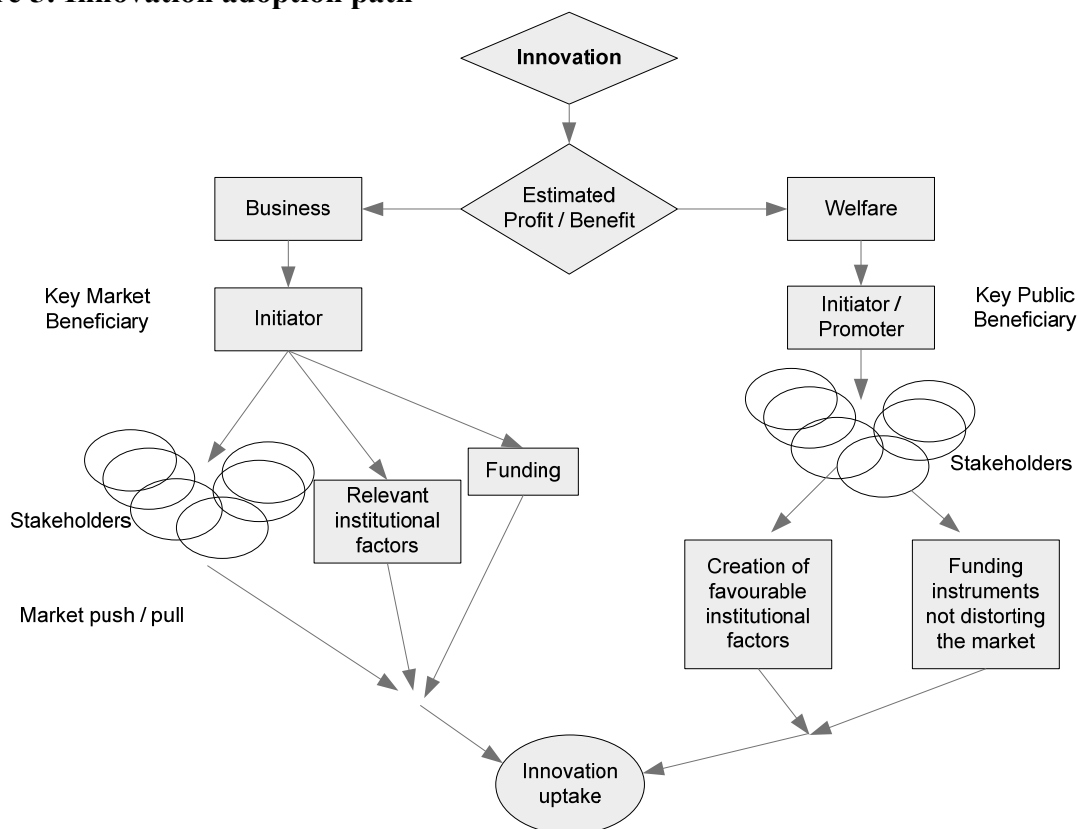
2.1.4.3 Implementation/termination period

- Adoption and implementation occurs throughout the development period by linking and integrating the “new” with the “old” or by reinventing the innovation to fit the local situation.
- Innovation stops when it is implemented and institutionalized. In other words when the innovation is not an innovation anymore but considered as common practice. Or it

stops when resources run out before the innovation is completed or redesigned. Investors/top managers make attributes about success/failure.

Depending on the outcomes of the innovation, it can produce profit and/or welfare. Depending on this, for the innovation uptake different paths can be defined. Those are summarized in Figure 5 below.

Figure 5: Innovation adoption path



Source: InnoSuTra project deliverable D6, Arduino *et al.* (2011b)

2.1.5 The Systems Innovation approach⁵

The SI approach has its roots in the evolutionary theory of Nelson and Winter (1982) and since its emergence in the early 1990's, it has attracted the interest of policy makers, especially of international policy think-tanks such as the OECD (Mytelka and Smith (2002)). In the SI approach, firms are a bundle of different capabilities and resources (Eisenhardt and Martin (2000); Grant (1996); Spender (1996)), which they use to maximize their profit. Knowledge is not only information, but also tacit knowledge; and can be both general and specific and is always costly. Knowledge can be specific to the firm or to the industry (Smith (2000)). While in the neoclassical approach, information asymmetries are considered to be a market failure, under the evolutionary theory they are a source of innovation.

In the SI approach, innovation does not take place in isolation. Actors, within the system, interact, cooperate and learn (Lundvall (1992)). Hard (regulations, laws etc.) and soft (cultural norms, values, codes etc.) institutional structures are crucial to economic behaviour

⁵ Adopted with modifications from InnoSuTra project deliverable D6, Arduino *et al.* (2011b).

and performance and formulate the “rules of the game” or “code of conduct” (Smith (1997)). The system evolves, generates variety and selects across that variety and produces feedback (Hauknes and Nordgren (1999)). This process of novelty and variety creation is the result of constant interaction among heterogeneous actors in a population and is necessary to maintain the diversity that makes selection possible (Nelson (1995); McKelvey (1997); Smith (2000)). Hence, under the SI approach asymmetries are essential in providing novelty and variety. This is the very contrast with neoclassical theory, where the objective is equilibrium, which may be achieved under conditions of perfect information, perfect competition and profit maximization.

Under neoclassical theory, public policy (measures) intervenes to mitigate non-desired externalities and asymmetries in information, to correct inefficient market structures or eliminate the barriers to entry so that the markets can reach the desired equilibrium, Smith (2000). Evolutionary theory puts the emphasis on the mechanisms of diversity creation and selection (e.g. competition) as the engines of innovation. It also stresses the path- dependency of innovation processes. The SI approach, takes the evolutionary theory as one of the points of departure, to focus on the interactive mechanisms that shape the emergence and diffusion of innovations. This is achieved through the interaction of actors and institutions. Different actors and/or different institutions form different Systems of Innovation. In all these basic elements, systemic imperfections (or systemic problems) can occur if the combination of mechanisms is not functioning efficiently. If so, innovation by actors may be blocked. These systemic problems mentioned in the literature as summarized by Hauknes and Nordgren (1999), Smith (2000), Woolthuis *et al.* (2005) and Edquist and Chaminade (2009) include:

1. *Infrastructural failures*: The physical infrastructure that actors need to function (such as IT, telecom, and roads) and the science and technology infrastructure
2. *Transition failures*: The inability of firms to adapt to new technological developments.
3. *Lock-in/path dependency failures*: The inability of complete (social) systems to adapt to new technological paradigms.
4. *Hard institutional failure*: The failures in the framework of regulation and the general legal system. These institutions are specifically created or designed, i.e. formal institutions
5. *Soft institutional failure*: The failures in the social institutions such as political culture and social values, i.e. informal institutions.
6. *Strong network failures*: The ‘blindness’ that evolves if actors have close links and as a result miss out on new outside developments.
7. *Weak network failures*: The lack of linkages between actors as a result of which insufficient use is made of complementarities, interactive learning, and creating new ideas. The same phenomenon is referred to as dynamic complementarities’ failure (Malerba, 1997).
8. *Capabilities’ failure*: Firms, especially small firms, may lack the capabilities to learn rapidly and effectively and hence may be locked into existing technologies/patterns, thus being unable to jump to new technologies/business patterns.

Within the SI approach, policy interventions (Edquist and Chaminade (2009)) are needed either because: (i) there is no market mechanism operating at all and the activities are fulfilled through other mechanisms, e.g., regulation or (ii) the market mechanism does not lead to the fulfillment of the objectives established. In both cases, public intervention should lead to “*additionality*” and not “*substitution*” of market activities.

Conceptualizing the system of innovation is not straightforward, as, on the one hand, it evolves over time with many feedback loops, and on the other, it evolves within an internal and external environment (Edquist (2005)). Defining the boundaries of the system and its environment is equally important in the analysis (Markard and Truffer (2008)). Simultaneously, the feasibility of alternative directions for innovation must also be evaluated (Edquist and Hommen (1999)).

A system in general is an entity comprising elements that interact with one another. Innovation systems can be conceptualized as a set of organizations and institutions and the relationships among them (Edquist (2005)). Organizations typically encompass private firms or firm sub-units, governmental and non-governmental agencies, universities, research facilities, venture capitalists, associations, etc. Institutions, may be regarded as the “rules of the game”, comprising laws and regulations, socio-cultural as well as technical norms, use patterns, shared expectations, etc.

The relationships among the system components, i.e. among actors, among institutions but also between actors and institutions, are manifold. The analysis of such a system is not without difficulty as actors are embedded in the institutional context. Actors, however, may also deliberately change or adapt existing institutions or create new ones, which means that there is a dual subject–object relationship between actors and institutions (‘mutual embeddedness’, see Edquist and Johnson (1997)).

Woolthuis *et al.* (2005) proposed a system failure framework for innovation policy design by suggesting a matrix representation of actors and institutions where system failures could be identified. This matrix approach, as described in section 3.3, is used for this doctoral research with the aim of determining the system success conditions and not failures.

2.1.6 Management theories

2.1.6.1 Stakeholder theory

Donaldson and Preston (1995) give an overview of the stakeholder theory. They acknowledge that stakeholder management contributes to successful economic performance of projects, but argue that this statement is insufficient to stand alone as a basis for the stakeholder theory and that ultimate justification for the stakeholder theory is to be found in its normative base. DiMaggio and Powell (1983) seek to explain homogeneity of organizations. They investigate mechanisms behind isomorphic change of organizations – why there is such startling homogeneity of organizational forms and practices.

Mitchell *et al.* (1997) propose a classification of stakeholders based on power to influence, the legitimacy of each stakeholder’s relationship with the organization, and the urgency of the stakeholder’s claim on the organization. This approach allows assessing which stakeholders require the attention of the innovator, and which do not. This is used in the methodology of this research to determine the priorities for managerial attention.

2.1.6.2 Neo-institutionalism theory

Neo-institutionalism is theory that develops a sociological view of institutions and investigates the way they interact and the way they affect society.

Meyer and Rowan (1977) observed that "organizations that incorporate societally legitimated, rationalized elements in their formal structures maximize their legitimacy and increase their resources and survival capability." O'Connell *et al.* (2005) argue that confronted by a field composed of activist stakeholders, organizations will reflect the interests of many actors and not just those of management. This is because in the new institutionalism, success has no simple measure, as different stakeholders ask for different types of performances before signalling acceptance of the organization's activities. Success depends in part at least on the ability to instil confidence in particular stakeholders that the focal organization is well run. According to DiMaggio and Powell (1983), external stakeholders play a central role in determining the norms and structures that are required for success.

2.1.6.3 Institutional entrepreneurship

The concept of institutional entrepreneurship has emerged to help answer the question of how new institutions arise: institutional entrepreneurship represents the activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones, Maguire *et al.* (2004).

Maguire *et al.* (2004) identified two patterns in the data that showed how the practices came to be accepted and taken for granted. In brief, the new practices were institutionalized by attaching them to pre-existing organizational routines and by reaffirming their alignment with important stakeholder values on an ongoing basis.

2.2 Applicable measures for tackling congestion

A range of literature on possible measures for tackling congestion problems on road transport infrastructure is available. The literature review focuses on sources covering the most important approaches used for capacity optimisation, which are usually considered by the policymakers: infrastructure measures, road pricing and regulatory measures.

2.2.1 Infrastructure measures

Expansion of existing road capacity has been the traditional response to growing congestion. It is also often considered an important determinant of economic growth and means for lowering social inequality, see Lopez (2003), Kerali (2003) and Calderon and Serven (2005). Of course, constraints that construction of new roads can face should be taken into account, like shortage of public funds, space and environmental concerns.

Road infrastructure expansion can also have unwanted effects, for example Thomson (1977) demonstrates that road infrastructure extension diverts users of alternative modes back to road transport.

According to Chen and Bernstein (2004), expansion of infrastructure capacity may be impractical in many urban areas. It is usually assumed that increase of transport demand is never-ending, but Zumkeller *et al.* (2004) show with an example of passenger travel demand in Germany that it is not necessarily true, and that road infrastructure development should not be based on the idea of everlasting growth of traffic.

For evaluation of transport infrastructure policies in the European Union, Kohler *et al.* (2003) and Tavasszy *et al.* (2004) can be consulted.

2.2.1.1 Latent/induced demand

Latent or induced demand is defined as the increment of new vehicle traffic that would not have occurred at all without the capacity improvement, Mokhtarian *et al.* (2002).

In the context of expansion of infrastructure capacity, evaluation of induced demand may be important, because it would have an effect on the evaluation of outcomes of the project, including effects on cost-benefit analysis and the environment.

In Cohen (1995), Goodwin (1996) and Mokhtarian *et al.* (2002) reviews are available of some older sources covering the complex problem of induced demand. A more country-specific review of different sources by Noland and Lem (2002) is available for UK and US. Also, some country-specific research is available focusing on the phenomenon in developing countries like the one by Ozuysal and Tanyel (2008) focusing on Turkey. Most of the researchers agree on the existence of induced demand in case of infrastructure capacity improvement since early studies (e.g. Jorgensen (1947), Lynch (1955)), however the findings of empirical studies diverge on its level. For example, Kroes *et al.* (1996), Samaniego *et al.* (1999) find no significant induced demand, but most like Goodwin (1996) find it to be at a level worth considering.

From the above it can be concluded that building extra infrastructure is not only costly, but has some undesired side effects. Therefore for tackling congestion one should look for alternative measures next to infrastructure construction and upgrades.

2.2.2 Road pricing

Smith (1776) in “An Inquiry into the Nature and Causes of the Wealth of Nations” devotes several pages to transportation projects. He is the first to propose the road pricing as an option to recover the investment cost: “*The greater part of such public works may easily be so managed as to afford a particular revenue sufficient for defraying their own expence, without bringing any burden upon the general revenue of the society.*”

Later Dupuit (1844) built models to determine the toll that would allow recovering the costs and an optimal toll for a monopoly to maximise profits. He analyzed potential price discrimination options.

Pigou (1920) suggested tolls on public roads to tackle congestion. In his book “The Economics of welfare” developed Alfred Marshall’s concept of externalities, costs imposed on others that are not taken into account by the person taking the action. Pigou outlined a situation of misallocation of resources that results from free public roads: “*Suppose there are two roads, ABD and ACD both leading from A to D. If left to itself, traffic would be so distributed that the trouble involved in driving a “representative” cart along each of the two roads would be equal. But, in some circumstances, it would be possible, by shifting a few carts from route B to route C, greatly to lessen the trouble of driving by those still left on B, while only slightly increasing the trouble of driving along C. In these circumstances a rightly chosen measure of differential taxation against road B would create an “artificial” situation superior to the “natural” one. But the measure of differentiation must be rightly chosen.*” Knight (1924) in his article “Fallacies in the Interpretation of Social Cost” challenged Pigou’s view that traffic congestion justifies taxation of roads. He argued that if roads were owned

privately then the profits from tolls would help to reduce congestion at the same time reaching “*ideal*” optimum and therefore making the government intervention unnecessary.

Until early 1960s Pigou’s views were widely accepted when Coase (1960) showed with an example from agriculture that taxes and subsidies are not necessary if people affected by externality and people who cause it can bargain over the transaction. Pigou’s reliance on taxes and subsidies was further undercut by public choice economists⁶ like Buchanan and Tullock (1962) who observed that governments tend to fail reaching Pareto optimality.

2.2.2.1 Peak load problems

Bye (1926) was the first to talk about nature of cost related to scarcity of resources. Later Boiteux (1960) discusses peak load problems and pricing possibilities in the electricity sector. Steiner (1957) expands and elaborates on these problems talking about products or services that are technologically not storable as with electric power and transportation, both inter- and intra-urban.

2.2.2.2 Marginal cost pricing

Walters (1961) discussed the applicability of marginal cost pricing on the highways to deal with peak-load problems. Based on empirical evidence he proposes the use of gasoline taxes and special tolls in congested areas (he also calculates proposed levels for those). Mohring and Harwitz (1962) were the first to show that optimal pricing and investment decision for highways can be dealt with analytically in a single model. They concluded that *in the case of constant long-run average cost, the revenue raised from optimal toll exactly covers the capital cost of providing a road of optimal width*, which is known as the ‘self-financing’ result. A geometric derivation of this can be found in Arnott and Kraus (2003). The model was extended by Vickrey (1963), Strotz (1965) and Mohring (1970) to include peak load pricing. Several other papers, including those by Mohring and Harwitz (1962) Vickrey and Sharp (1968), Johnson (1964), Mohring (1965), Keeler and Small (1977) and De Vany and Saving (1980) elaborated the results.

In practice according to Nash and Sansom (2001) marginal cost pricing would require highly differentiated pricing systems which would be expensive in implementation and confusing to users.

2.2.2.3 Second-best pricing

The theory relates to first-best pricing where congestion is the only externality. When road usage is linked with other externalities in practice according to Diamond and Mirrlees (1971) second-best theory is applied. It is shown in examples of Levy-Lambert (1968) and Marchand (1968) that underpricing of urban auto travel may be linked with underpricing of public transport. Second best theory is also applied in Atkinson and Stiglitz (1980) on charging lower fares to needy groups, Wilson (1993) on nonlinear pricing, Mohring (1970) on variations of Ramsey pricing⁷, and Boiteux (1956) on authority facing deficit constraint requiring it to set the price above marginal social cost. Vickrey (1959) stated that *with distortional taxation the social cost of financing an extra dollar of transit authority deficit may significantly exceed one dollar*. In the example of Laffont *et al.* (1994) government

⁶ Public choice economists use economic tools to study problems that are traditionally in the field of political science.

⁷ Proposed by Frank Ramsey. Pareto optimal for a single supplier subject to a constraint on the total profits. If prices are to be set above marginal costs, the increase should be largest for the goods with most inelastic demand, because consumers will buy them anyway.

chooses to deviate from marginal cost pricing to provide the public transport authority with higher-powered incentives or to achieve political objectives.

Since the 90ties second-best pricing had ample attention in literature. The main reason for this according to Verhoef (2002) is that first-best pricing policy for a congested road network is a rather theoretical concept and transport regulators often consider second-best solutions only. Examples of second-best pricing mentioned in Small and Gomez-Ibanez (1998) include pay-lanes, toll cordons, parking charges, area permits and others.

The classic two-road problem (see above) where an untolled alternative road is available parallel to a tolled road is also discussed in the second-best pricing context in various articles. Some sources to be mentioned here are Braid (1996), Verhoef *et al.* (1996), Liu and McDonald (1998),(1999), de Palma and Lindsey (2000) and Verhoef and Small (1999).

Glazer and Niskanen (1992) consider the relationship between the price of parking and traffic congestion, and discuss how first-best parking fees should be modified when traffic congestion is not priced.

Verhoef *et al.* (1996) show how the second-best toll on the tolled route differs from the first-best toll, that it may be negative in order to discourage usage of the untolled route. Building on that Verhoef (2002) presents an algorithm for determining optimal toll levels and toll points for transport networks. Chen and Bernstein (2004) also look at the road network, but they propose a methodology for a realistic case where only a small number of links can be tolled.

2.2.2.4 Practical implementation

A range of examples is available of practical implementation covering cities or areas around the world. These implemented pricing schemes can be classified based on their geographical characteristics. Here a classification adopted from de Palma and Lindsey (2009) is used in order of increasing scale to show some well-known implementation examples.

2.2.2.4.1 Facility-based schemes

Facility based schemes have historically been and still are the most common form of road pricing. They are imposed on roads, bridges and tunnels. Tolls are levied either on all lanes or some lanes of the facility. Toll collection can be organized in a single point of the facility or at multiple points.

2.2.2.4.2 Cordons

Cordons are a form of area-based pricing where the drivers must pay to cross the cordon to enter the area, but sometimes also to exit the area or cross the cordon. Theoretically, cordon scheme pricing can include multiple circular cordons with radial screenlines to control orbital movements. By simulating cordon tolls for eight English towns, Santos (2004) compares cordon pricing to first-best pricing and concludes that cordon tolls perform relatively well. The first cordon based schemes were introduced in Norway: Bergen in 1986, Oslo in 1990 and Trondheim in 1991. The objective of toll cordons in Norway was to raise money for road building and the design of the schemes reflects this fact – an overview is available in Larsen (1995).

A cordon scheme to manage congestion was set up in Stockholm in 2006 as a trial, see Eliasson *et al.* (2009). Later it was reintroduced as a permanent scheme, see Eliasson (2009).

The Electronic Road Pricing scheme launched in Singapore in 1998 is a hybrid of facility-based tolls and cordons, since it covers certain expressways, but also has three restricted zones and a cordon. Details can be found in Goh (2002).

2.2.2.4.3 Zonal schemes

In case of zonal schemes, the users pay to enter or exit a zone, but also for travelling inside a zone without crossing its boundary. The only operational zonal congestion pricing scheme is the London congestion charge, introduced in 2003⁸. Contradictory research reports are available on the systems performance. Analysis carried out by Transport for London (2003) estimates a yearly benefit of 70 million €, however according to a study of Prud'homme and Bocarejo (2005) a net yearly loss of 80 million € is obtained. The difference in those results is explained by Mackie (2005) and Raux (2005). A summary of experiences that London, Stockholm and Singapore have had is done by Aas *et al.* (2009).

2.2.2.4.4 Distance-based schemes

In distance-based schemes the charges paid vary linearly or nonlinearly with distance travelled. In the US four states have implemented distance or weight based charges, see Conway and Walton (2009). The purpose of these in the US is to recover infrastructure costs and not to manage demand.

In Europe national distance-based schemes exist in Switzerland (see Balmer (2003)), Austria and Germany (see Doll and Link (2007); Broaddus and Gertz (2008)), but several other countries are developing or considering them. Every country uses a different technology. Therefore lack of interoperability of the different charging systems in Europe is perceived as a major disadvantage, Link and Stewart-Ladewig (2006).

2.2.2.5 Technologies employed

Vickrey (1965) proposed possible technologies that could be employed for collecting road charges, including differentiating for peak and off-peak hours. Since then significant technological developments have taken place. Currently available technologies for implementation are listed and described in de Palma and Lindsey (2009).

2.2.3 Summary of applicable measures reviewed

Table 3 below presents a summary of the reviewed measures that are applicable. It summarizes the impacts a measure would have and the conditions required for its implementation. It also mentions to which of the applicable measure types the measure belongs. This summary table will provide input for developing a policy measure for dealing with the concrete situation of congested port hinterland links in the case study that is investigated in further chapters of this thesis.

⁸ Transport for London (2009), <http://www.tfl.gov.uk/roadusers/congestioncharging/>, 08.10.2009.

Table 3: Summary table of applicable measures reviewed

Measure	Type*	Literature sources	Impacts / evaluation	Conditions / inputs needed / aspects to consider
Marginal cost pricing	P	Walters (1961), Mohring and Harwitz (1962), Arnott and Kraus (2003), Vickrey (1963), Strotz (1965), Mohring (1970), Mohring and Harwitz (1962), Vickrey and Sharp (1968), Johnson (1964), Mohring (1965), Keeler and Small (1977), De Vany and Saving (1980), Nash and Sansom (2001), Kohler <i>et al.</i> (2003)	<ul style="list-style-type: none"> - Reduction in the density of traffic, Walters (1961) - Efficiency in reallocating traffic volumes, Liu and McDonald (1999) - The tolls are higher than second-best tolls, Liu and McDonald (1999) - Higher welfare gains than those possible with second-best tolls, Liu and McDonald (1999) - Diversion of traffic between different transport modes, Tavasszy <i>et al.</i> (2004) - The first-best scheme is more efficient than second-best schemes in reallocating traffic volumes, Liu and McDonald (1999) - When modelled the net impact of introduction of marginal social cost pricing policy in the EU is positive in every country, Kohler <i>et al.</i> (2003) 	<ul style="list-style-type: none"> - It should be selective and discriminatory according to both the time of day and the location of the road, Johnson (1964) - Requires different levels of taxes at any given speed, Johnson (1964) - In practice marginal cost pricing would require highly differentiated pricing systems which would be expensive in implementation and confusing to users, Nash and Sansom (2001) - Impossible to implement because policymakers are generally restricted to place tolls on only a very limited roadway links such as bridges and tunnels, Chen and Bernstein (2004)
Second best pricing	P	Diamond and Mirrlees (1971), Levy-Lambert (1968), Marchand (1968), Atkinson and Stiglitz (1980), Wilson (1993), Mohring (1970), Boiteux (1956), Vickrey	<ul style="list-style-type: none"> - A viable alternative to reduce congestion, Chen and Bernstein (2004) - Parallel route pricing schemes – in particular pay-lanes – constitute a relatively inefficient type of second-best congestion pricing, Verhoef (2002) 	<ul style="list-style-type: none"> - Allows a limited set of links in the network to be tolled, Chen and Bernstein (2004) - Second-best pricing schemes are more suited for implementation than marginal

Measure	Type*	Literature sources	Impacts / evaluation	Conditions / inputs needed / aspects to consider
		(1959), Laffont <i>et al.</i> (1994), Verhoef (2002), Small and Gomez-Ibanez (1998), Braid (1996), Verhoef <i>et al.</i> (1996), Liu and McDonald (1998), (1999), de Palma and Lindsey (2000), Verhoef and Small (1999), Glazer and Niskanen (1992), Verhoef <i>et al.</i> (1996), Verhoef (2002), Chen and Bernstein (2004)	<ul style="list-style-type: none"> - Toll roads are found to generate substantially higher efficiency gains when tolls are varied over time to prevent queuing than when a (time-invariant) tolling is adopted, de Palma and Lindsey (2000) - The second-best scheme is effective but less efficient than the first-best scheme in reallocating traffic volumes, Liu and McDonald (1999) - The second-best tolls are appreciably smaller than the first-best tolls, Liu and McDonald (1999) - The welfare gains from the second-best policy are much smaller than the welfare gains that are possible with a complete set of first-best tolls, Liu and McDonald (1999) - Second-best policies are not only less efficient <i>per se</i>, but may in addition yield even smaller net benefits because information needed to efficiently apply the instrument available is lacking, Verhoef and Small (1999) - Historically the first pricing schemes in place, used for infrastructure cost recovery, one of second best pricing instruments 	<ul style="list-style-type: none"> - cost pricing
Facility-based pricing schemes	P			
Cordons and zonal schemes	P	Santos (2004), Larsen (1995), Eliasson <i>et al.</i> (2009),	<ul style="list-style-type: none"> - Increased welfare of the residents, Safirova <i>et al.</i> (2006) 	<ul style="list-style-type: none"> - Proposals for implementation can face strong opposition

Measure	Type*	Literature sources	Impacts / evaluation	Conditions / inputs needed / aspects to consider
		<p>Eliasson and Hugosson (2006), Eliasson (2009), Goh (2002), Aas <i>et al.</i> (2009), Safirova <i>et al.</i> (2006), Transport for London (2003), Prud'homme and Bocarejo (2005), Mackie (2005), Raux (2005), Aas <i>et al.</i> (2009)</p>	<ul style="list-style-type: none"> - Decline of traffic volumes, especially in the interior of the cordon. Increase of accessibility, Eliasson and Hugosson (2006) - Improvements in road safety, Eliasson and Hugosson (2006) - Lead to GDP growth in the region, Safirova <i>et al.</i> (2006) - Larger and double cordons lead to higher benefits than a small cordon encompassing downtown core, Safirova <i>et al.</i> (2006) - Negatively affects economic activity within the boundary, Safirova <i>et al.</i> (2006) - Effective means for reducing traffic queues during rush hour, Eliasson (2009) - Can yield significant environmental benefits, Eliasson (2009) - Unequal distribution of burden on different groups – unfair social impact - Allows time (and therefore cost) savings for businesses - Reduces need for investments in infrastructure 	<p>from the public so strong political will is necessary for implementation</p>
Distance-based schemes	P	Conway and Walton (2009), Balmer (2003), Doll and Link (2007), Broadbuss and Gertz (2008), Link and Stewart-	<ul style="list-style-type: none"> - Short term (3 months): hauliers pass on extra costs to clients, route changes to avoid tolls, cost cuts on maintenance, temporary acceptance of lower margins, 	<ul style="list-style-type: none"> - Requires country-wide implementation - Associated with investments in toll collection infrastructure

Measure	Type*	Literature sources	Impacts / evaluation	Conditions / inputs needed / aspects to consider
		Ladewig (2006), Van der Linde (2003)	<ul style="list-style-type: none"> - Van der Linde (2003) Medium term (1-2 years): hauliers perform reorientation of core business, mode shift, forming alliances, investment in structural lowering of kilometre costs, Van der Linde (2003) - Long term: reorganization of logistics networks, relocation of facilities, shortening transport distances, Van der Linde (2003) 	
Developments in European policy	R	Nash and Sansom (2001), Tavasszy <i>et al.</i> (2004), Kohler <i>et al.</i> (2003)	<ul style="list-style-type: none"> - Effects of change of split between different transport modes, Tavasszy <i>et al.</i> (2004) - Switch to larger but cleaner vehicles, Tavasszy <i>et al.</i> (2004) - Changes in pattern of economic activity with more local economic activity, Tavasszy <i>et al.</i> (2004) - Reduction of transport externalities mainly in core European countries, Tavasszy <i>et al.</i> (2004) - Increase of costs for peripheral countries, Tavasszy <i>et al.</i> (2004) 	<ul style="list-style-type: none"> - Not consistent with the principles of marginal cost pricing. Nash and Sansom (2001) - There is long-term emphasis on full cost recovery in many countries. Nash and Sansom (2001) - There have been major problems in the road freight sector, caused by the fact that different countries have very different methods and levels of charging for infrastructure use. Nash and Sansom (2001)
Infrastructure extension	I	Yang <i>et al.</i> (1996), Lopez (2003), Calderon and Serven (2005)	<ul style="list-style-type: none"> - Increment of transport convenience, reduction of transport time or cost, Yang <i>et al.</i> (1996) - Road infrastructure improvement may have an effect on regional economy 	<ul style="list-style-type: none"> - Requires considerable investments - Expanding infrastructure capacity may be impractical in many urban areas, Chen and

Measure	Type*	Literature sources	Impacts / evaluation	Conditions / inputs needed / aspects to consider
			<p>through reduction in transport time and costs, and such a reduction leads to expansion of markets, Yang <i>et al.</i> (1996)</p> <ul style="list-style-type: none"> - Enterprises will benefit from this increased accessibility, they will be induced to change their locations accordingly, Yang <i>et al.</i> (1996) - Land value changes will occur, Yang <i>et al.</i> (1996) - Economic growth is positively affected by the stock of infrastructure assets, Calderon and Serven (2005) - Income inequality declines with higher infrastructure quantity and quality, Calderon and Serven (2005), Lopez (2003) 	<p>Bernstein (2004)</p> <ul style="list-style-type: none"> - Road infrastructure extension diverts users of alternative modes to road transport, Thomson (1977)
Fuel tax	P		<ul style="list-style-type: none"> - Taxes on gasoline appear to be ineffective weapons against traffic congestion since this unit tax discourages motoring in general but not at the particular times or places where congestion exists, Johnson (1964) 	

* I – infrastructure, P – pricing, R – regulatory

2.3 Influencing factors

Factors exist that are external to the innovation itself, but have influence on the development path and, most importantly, success of the innovation. Those factors are different developments in the economy and could be global, like the global economic growth, but also local like developments in local transport infrastructure. With the focus on the port hinterland situation investigated in this research, these possible influencing factors are outlined. This step is necessary in order to select and quantify variables for the modeling stage of the research, methodology for which is described in CHAPTER 3, section 3.1 of this thesis.

2.3.1 Key logistics drivers

The 32 literature sources reviewed here take different approaches in developing future scenarios. Table 35 (see Annex 1 on page 199), presents a summary of the most frequently quoted/identified key drivers in the literature for the area that was being analyzed, paying special attention to the literature referring to the transport sector. An organization's strategy often leads to unexpected advantages and opportunities resulting from the complex interplay with macro factors (Singh (2004)). Therefore, to predict the future it is not sufficient to focus only on the likelihood of macro factors. One also has to consider the emerging concepts that will dominate the future and the practices in the transport sector that in return will influence the macro factors.

As can be observed from Table 35, the key drivers were classified as macro and industry factors. Macro factors are the likely drivers of future changes that will affect all sectors of the economy, while industry factors are those drivers that relate to key strategic or operational shifts within the sector.

The literature review shows that concerns over environmental issues and the cost of externalities as congestion and pollution are becoming more and more relevant in the analysis of future scenarios. Expected policy measures over these matters are likely to affect considerably the future evolution of infrastructure investment and pricing policies.

2.3.2 Port Traffic

The Port of Antwerp, which is in the focus of the case study investigated in this research, is the second largest port in Europe for international freight shipping. Its one of the main hinterland road links in the East direction is the motorway E313. It is depicted on the map in Figure 10 on page 69. Mode split data (in TEU) for recent years show that ~60% of the container turnover that is generated by the Port of Antwerp is transported to/from the port by road overall and a big part of it is transported via this road.

Based on an analysis for the period 2001-2007 of the historic data on port turnover for the Port of Antwerp, traffic count data obtained from the Flemish Traffic Centre on heavy goods vehicle traffic, and results from simulations with the Freight model Flanders, there seems to be a relation between the traffic volumes of those vehicles on the E313 motorway and the port turnover, although not very pronounced. The forecast increase in port traffic may therefore have an effect on the heavy goods vehicle traffic on the E313 motorway.

Short Sea Shipping holds an important share of the transport market within the European Union. According to European Commission, it represents 40% of the intra-EU exchanges in terms of tonne-kilometres. The relevance of this transport mode in for the EU policies was emphasized by the European Commission in its “White Paper on European Transport Policy 2010” and in “White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system” (European Commission (2001); European Commission (2011)).

Although SSS may reduce the share of road traffic overall, it induces local concentrations of traffic, from and to ports. This for sure also affects the port hinterland connections. Therefore, trends of increase in SSS should be taken into account, although the exact magnitude of the impacts is not certain.

2.3.3 The Albert Canal

The Albert canal is a direct competitor to the E313 motorway. A project to increase the capacity of the Albert Canal was started and requires the replacement of a number of bridges. Modernization of the Albert Canal waterway for navigation of vessels of up to 9,000 t carrying capacity will allow barges to sail with containers stacked up to four high. The work that is in progress includes the elimination of a bottleneck between Wijnegem and Antwerp, where the Canal is barely navigable for vessels of class Va, whereas the rest of the Canal is suited for class VIb vessels and push convoys. Moreover, on this section, the bridges have the lowest clearance, some less than 7 m, which is the standard for three-layer container navigation only. Eliminating these barriers will open up the Albert Canal for bigger and wider vessels and will allow full use of the Canal on its total length. The project includes the widening of the Canal up to a minimum width of 63 m. The works are scheduled to end by September 2014. (United Nations Economic and Social Council (2006); European Commission (2008a); De Scheepvaart, nv (2008); Infrabel (2012))

2.3.4 Iron Rhine

Just like the Albert Canal, the Iron Rhine is also a potential competitor to the E313 motorway. It is the historic railway line, built in 1879, that runs from Antwerp to Duisburg. Since 1991 this track has not been used anymore for international trains. From Antwerp the track runs through, among others, Lier, Budel, Weert and Roermond and ends in Mönchengladbach. The complete track has a length of 162 km of which 96 km is located in Belgium, 48 km in the Netherlands and 18 km in Germany.

Currently, Antwerp port-related traffic uses the Montzen route, south of the Iron Rhine, from Antwerp to Aachen via Aarschot, Hasselt, Tongeren and Montzen, for transportation of goods to Germany. High passenger traffic on parts of this route causes a lack of capacity for goods. Moreover, a number of steep slopes over the route make it problematic for long and heavy trains to pass. In 2004, Belgium requested a reopening of the Iron Rhine.

In 2006 it was concluded that by the year 2020, in a situation where the Iron Rhine is reactivated, the line is expected to attract between 9.4 and 12.3 million tonnes on the section crossing the Dutch-Belgian border. Most of the traffic, approximately 80%, is estimated to be diverted away from the Montzen route. Freight transport from other competing rail lines would also be attracted, e.g. from the route from Belgium via Luxemburg to Germany and the Brabant route. A slight mode shift of 0.3 to 0.4 million tonnes towards rail will also occur,

mainly diverted away from inland shipping. By year 2030, the volume of freight transported over the Iron Rhine will have increased to between 10.8 and 17.2 million tonnes. Recent analyses also show that economic viability at short notice of this project, under current market and operating conditions, is not evident. (NEA Transport research and training and Universiteit Antwerpen (2007); Transport & Mobility Leuven (2007))

2.3.5 European Developments

In recent years, the European Union has been enacting different transport policies. The EU legislation and developments that may have the biggest influence on the further development of the situation in a port hinterland are the following:

1. Taxation of heavy goods vehicles: “Eurovignette” Directive
Directive 1999/62/EC of the European Parliament and of the Council of 17 June 1999
Amending acts: directive 2006/38/EC and directive 2006/103/EC.
The Directive covers vehicle taxes, tolls and user charges imposed on vehicles intended for the carriage of goods by road and having a maximum permissible gross laden weight of not less than 12 tonnes. From 2012 onwards, Directive 2006/38/EC will apply to vehicles weighing between 3.5 and 12 tonnes.

Proposal for a Directive on road tolls for lorries (amending 1999/62/EC)
This proposal would enable Member States to reduce environmental damage and congestion through more efficient and greener road tolls for lorries. Revenue from the tolls would be used to reduce environmental impacts and cut congestion. This proposal is part of Greening Transport Package (adopted 8 July 2008). (European Commission, 2008b)
2. TEN-T plans
The TEN-T network axis with most impact to the E313 motorway are rail axis nr. 24 Lyon/Genova – Basel – Duisburg - Rotterdam/Antwerp, which includes the Iron Rhine Rheidt-Antwerp railway and inland waterway axis nr.18 Rhine/Meuse-Main-Danube with sub-section Albert canal. Other TEN-T network links have little or no impact on the E313 motorway.
3. Road safety: Road Safety Action Programme (2003-2010)
Main measures: to propose a Directive on road infrastructure safety, draw up technical guidelines concerning audit methods, urban safety management and speed-moderation techniques, draw up good practice guidelines for level-crossings, carry out research and demonstration projects on 'intelligent roads', carry out safety impact assessments of new projects, improve safety levels in tunnels, etc. (European Commission, 2003)
4. Road vehicles: maximum weights and dimensions
Council Directive 96/53/EC of 25 July 1996 laying down for certain vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic.
Amending act: Directive 2002/7/EC

2.3.6 Freight route/mode choice

The findings of different literature sources converge on the attributes that influence freight route or mode choice are similar to those investigated above. The most important factors according to Cullinane and Toy (2000), Cook *et al.* (1999), Jiang *et al.* (1999) and other sources include cost/price/rate, speed, transit time reliability, characteristics of the goods, and service level. It means that these are the factors that are considered when a shipper makes a decision about the mode/route choice that the goods should follow.

2.3.7 Port choice and competitiveness determinants

The study of Aronietis *et al.* (2009) shows that increases or decreases of port throughput have influence on incoming and outgoing goods flows on port hinterland connections. Therefore it can be important to investigate the determinants of port choice.

In the situation of fierce competition between ports, it is essential to identify the determinants of port competitiveness. In order to do that, a total of 30 references were used as the basis for the analytical review. Some older sources like Slack (1985), Branch (1986), Bird and Bland (1988), Frankel (1992), Murphy *et al.* (1992), Gibson *et al.* (1993), Murphy and Daley (1994) and Tongzon (1995) are reviewed, but main focus is on the most recent literature. The choice of sources was not constrained by geographical considerations.

2.3.7.1 Decision makers

The decision makers that are identified by the authors of the papers are: shippers, forwarders, shipping companies, terminal operators, port authorities and government agencies.

A major part – 15 of the studies - identify **shippers** as main or one of the decision makers in port selection. Studies done by Branch (1986), Murphy and Daley (1994), Kumar and Vijay (2002), Nir *et al.* (2003), Tiwari *et al.* (2003), Malchow and Kanafani (2001), (2004), Guy and Urli (2006), Ugboma *et al.* (2006) and Leachman (2008) focus only on shippers as decision makers in port selection. Other sources, like Slack (1985), Murphy *et al.* (1992), Song and Yeo (2004), Cullinane *et al.* (2005), De Langen (2007) and De Martino and Morvillo (2008) consider shippers, but also take into account other actors as decision makers for port selection.

The studies that evaluate **forwarders'** decisions in port selection are by Slack (1985), Murphy *et al.* (1992), De Langen (2007) and De Martino and Morvillo (2008); in these sources other actors are also considered. However in studies of Bird and Bland (1988), Tongzon and Sawant (2007), Tongzon (1995),(2009), Grosso and Monteiro (2008) forwarders are the only decision makers considered, and a survey is chosen as the method of research.

Eight of the sources (Murphy *et al.* (1992), Lirn *et al.* (2004), Ha (2003), Song and Yeo (2004), Shintani *et al.* (2007), De Martino and Morvillo (2008), Meersman *et al.* (2008)) also evaluate **shipping companies** as port choice makers. **Terminal operators** are mentioned only in four sources (Song and Yeo (2004), Acosta *et al.* (2007), Meersman *et al.* (2008), Wiegmans *et al.* (2008)). Only few (Frankel (1992), Cullinane *et al.* (2005), De Martino and Morvillo (2008), Meersman *et al.* (2008)) focused on port choice criteria influence by **government/port authority** decisions.

2.3.7.2 Literature reviewed in time

Shippers and shipping companies have been in focus of the researchers during the whole period covered by the literature reviewed (from mid 80s till 2009). For a brief period of time around 1990 (Bird and Bland (1988); Frankel (1992); Murphy *et al.* (1992)) and in recent years (De Langen (2007); De Martino and Morvillo (2008); Grosso and Monteiro (2008); Tongzon (2009)) literature focuses on forwarders. Terminal operators are evaluated as port choice decision makers since 2004 in the literature reviewed (Song and Yeo (2004); Acosta *et al.* (2007); Meersman *et al.* (2008); Wiegmans *et al.* (2008)).

2.3.7.3 Methodology

The most popular methodology for approaching the problem of determining port choice criteria is **surveying** the decision makers. This approach was taken in half of all the sources reviewed. Other approaches like **analytic hierarchy process, literature analysis, multivariate and discrete choice analysis** were also used by the authors in the literature reviewed.

2.3.7.4 Criteria

The literature reviewed reveals a considerable range of factors that have influence on the port choice. The most mentioned factors in order of citation times are: **cost, location, port operations quality / reputation, speed / time, infrastructure / facilities availability, efficiency, frequency of sailings, port information systems, hinterland / intermodal links and congestion in port**. Other port selection criteria are mentioned less than 3 times in the sources reviewed.

2.3.7.5 Importance of criteria for different actors

For different actors authors have focused on different criteria as important for port selection.

The criteria that are most mentioned as important to **shippers** (in order of citation times) are cost, port operations quality/reputation and port location. Of a bit less cited is frequency of shipping services, speed/time, efficiency of service, efficiency, port facilities/infrastructure, port information system, intermodal/hinterland connections, congestion in port, port services and flexibility (for special cargo).

According to literature the most mentioned criteria for **forwarders** are efficiency and port operation quality/reputation. Fewer times mentioned are cost, frequency, location, speed/time, port information systems and intermodal/hinterland connections.

For **shipping companies** criteria that are most mentioned (in order of citation times) are cost, location, port facilities/infrastructure and port operations quality/reputation. Criteria of lesser importance are speed/time, efficiency, congestion in port, frequency of shipping service, intermodal/hinterland links, port information systems, information availability, port administration, port services and flexibility for special cargo.

For **terminal operators** criteria that are mentioned as important (in order of citation times) are: port facilities/infrastructure, port operations quality/reputation, cost, location, intermodal/hinterland links, port information systems, congestion in port and efficiency.

The following Table 4 gives a summary of the literature reviewed.

Table 4: Summary of port choice criteria in literature reviewed

Source	Decision maker	Criteria	Methodology
Slack (1985)	<ul style="list-style-type: none"> • Shippers • Forwarders 	<ul style="list-style-type: none"> • Number of sailings • Freight rates • Congestion • Intermodal links 	<ul style="list-style-type: none"> • Survey
Branch (1986)	<ul style="list-style-type: none"> • Shippers 	<ul style="list-style-type: none"> • Cost • Nature of traffic • Adequacy of port facilities • Overall efficiency • Industrial relations record 	<ul style="list-style-type: none"> • n/a
Bird and Bland (1988)	<ul style="list-style-type: none"> • Forwarders 	<ul style="list-style-type: none"> • Frequency of shipping service • Port charges • Time • Grouping and freight consolidation • Labour problems at ports • Spirit of free enterprise • Delivered price 	<ul style="list-style-type: none"> • Survey
Frankel (1992)	<ul style="list-style-type: none"> • Governmental bodies • Shipping companies • Shippers • Freight forwarders 	<ul style="list-style-type: none"> • Liner companies revenues / costs / fleet size / fleet employment • Cargo volume / value / allocation 	<ul style="list-style-type: none"> • Analytic hierarchy process
Murphy <i>et al.</i> (1992)	<ul style="list-style-type: none"> • Large/small shippers • International water carriers • International water ports • International freights forwarders 	<ul style="list-style-type: none"> • Loading/unloading facilities for large/odd sized freight • Large volume shipments • Low loss and damage frequency • Available equipment • Convenient pickup and delivery times • Information concerning shipments • Assistance in claims handling • Flexibility in meeting special handling requirements 	<ul style="list-style-type: none"> • Survey • Univariate analysis • Multivariate factor analysis

Source	Decision maker	Criteria	Methodology
Murphy and Daley (1994)	<ul style="list-style-type: none"> • Purchasing manager (shipper) 	<ul style="list-style-type: none"> • Shipment information • Loss & damage performance • Freight charges • Equipment availability • Convenient pickup and delivery • Claims handling ability • Special handling ability • Large volume shipments • Large & odd-sized freight 	<ul style="list-style-type: none"> • Survey
Kumar and Vijay (2002)	<ul style="list-style-type: none"> • Shipper 	<ul style="list-style-type: none"> • On time performance • Value • Information technology • Customer service • Equipment and operations 	<ul style="list-style-type: none"> • Analytic hierarchy process
Mangan <i>et al.</i> (2002)	<ul style="list-style-type: none"> • Decision makers (on ferry choice) in transport companies 	<ul style="list-style-type: none"> • Service availability • Sailing frequency • Risk of cancellation • Fastest overall route • Proximity of ports to origin/destination • Cost • Speed of getting through ports • Suitability for special cargo • Delays • Intermodal/connecting links • Information availability 	<ul style="list-style-type: none"> • Modeling • Survey
Nir <i>et al.</i> (2003)	<ul style="list-style-type: none"> • Shipper 	<ul style="list-style-type: none"> • Highway travel time (origin: company, destination: port) • Travel cost • Number of available routes • Frequency 	<ul style="list-style-type: none"> • Survey • Revealed preference multinomial logical model
Lirn <i>et al.</i> (2004)	<ul style="list-style-type: none"> • Shipping lines 	<ul style="list-style-type: none"> • Physical infrastructure (including depth) • Geographical location (proximity to markets, main routes) • Port administration and service to vessels (turn around time) • Carriers cost per call 	<ul style="list-style-type: none"> • Analytic hierarchy process

Source	Decision maker	Criteria	Methodology
Tongzon (1995);(2009), Tongzon and Sawant (2007)	<ul style="list-style-type: none"> • Forwarders 	<ul style="list-style-type: none"> • Frequency of ship visits • Port efficiency • Adequate infrastructure • Location • Port charges • Quick response to port users' needs • Port's reputation for cargo damage 	<ul style="list-style-type: none"> • Survey
Ha (2003)	<ul style="list-style-type: none"> • Shipping companies 	<ul style="list-style-type: none"> • Information availability on port activities • Port location • Port turnaround time • Facilities available • Port management • Port costs • Customer convenience 	<ul style="list-style-type: none"> • Survey
Tiwari <i>et al.</i> (2003)	<ul style="list-style-type: none"> • Shippers 	<ul style="list-style-type: none"> • Ship calls (frequency) • Total TEUs handled at the port • TEUs per berth at the port • TEUs of cargo per crane • Handling volume (thousand tons) per length of quay • Number of routes offered • Port and loading charges 	<ul style="list-style-type: none"> • Literature review • Discrete Choice Analysis
Malchow and Kanafani (2001); (2004)	<ul style="list-style-type: none"> • Shippers (commodity types) 	<ul style="list-style-type: none"> • Distance • Frequency of sailings • Average size of vessel • Loading/unloading time 	<ul style="list-style-type: none"> • Discrete choice model
Song and Yeo (2004)	<ul style="list-style-type: none"> • Ship owners • Shipping companies • Shippers • Terminal operators • Academics 	<ul style="list-style-type: none"> • Cargo volume • Port facility • Port location • Service level • Port expenses 	<ul style="list-style-type: none"> • Analytic hierarchy process • Experts surveys
Cullinane <i>et al.</i> (2005)	<ul style="list-style-type: none"> • Shippers (demand trends) • Port authorities (supply) 	<ul style="list-style-type: none"> • Price • Generalized cost • Quality of service • Policy developments 	<ul style="list-style-type: none"> • Relative competitiveness analysis
Guy and Urli (2006)	<ul style="list-style-type: none"> • Shipping companies 	<ul style="list-style-type: none"> • Port infrastructures • Cost of port transit for a carrier • Port administration • Geographical location 	<ul style="list-style-type: none"> • Multicriteria analysis

Source	Decision maker	Criteria	Methodology
Ugboma <i>et al.</i> (2006)	<ul style="list-style-type: none"> • Shippers 	<ul style="list-style-type: none"> • Efficiency • Frequency of ship visits • Adequate infrastructure 	<ul style="list-style-type: none"> • Analytic hierarchy process
Acosta <i>et al.</i> (2007)	<ul style="list-style-type: none"> • Terminal operators 	<ul style="list-style-type: none"> • Infrastructure • Superstructure • Technology and communications systems • Internal competition • Cooperation of the institutions and companies involved in the port activity 	<ul style="list-style-type: none"> • Survey
De Langen (2007)	<ul style="list-style-type: none"> • Shippers • Forwarders 	<ul style="list-style-type: none"> • Location of port • Efficiency of cargo handling • Quality of terminal operating companies • Quality of equipment • Quality of shipping services • Information services in port • Good reputation to damage/delays • Customer focus • Connection to hinterland modes • Personal contacts in port 	<ul style="list-style-type: none"> • Survey
Shintani <i>et al.</i> (2007)	<ul style="list-style-type: none"> • Shipping companies 	<ul style="list-style-type: none"> • Costs • Empty container distribution 	<ul style="list-style-type: none"> • Algorithm-based heuristic analysis
De Martino and Morvillo (2008)	<ul style="list-style-type: none"> • Port authorities • Shippers • Forwarders • Shipping companies 	<ul style="list-style-type: none"> • Quality of the entire port: infrastructure, links to transport systems, terms of services • Value is generated by joint effort of port actors in the satisfaction of clients' needs 	<ul style="list-style-type: none"> • Literature review
Grosso and Monteiro (2008)	<ul style="list-style-type: none"> • Forwarding companies 	<ul style="list-style-type: none"> • Connectivity of the port • Cost and Port Productivity • Electronic information • Logistics of the container 	<ul style="list-style-type: none"> • Literature review • Survey
Leachman (2008)	<ul style="list-style-type: none"> • Importers 	<ul style="list-style-type: none"> • Transportation costs • Alternative routes • Door-to-door transit times • Shipments pooling • Lead times of container movement 	<ul style="list-style-type: none"> • Economic optimization model

Source	Decision maker	Criteria	Methodology
Meersman <i>et al.</i> (2008)	<ul style="list-style-type: none"> • Shipping companies • Terminal operating companies • Port authorities 	<ul style="list-style-type: none"> • Port hinterland connection capacity 	<ul style="list-style-type: none"> • Analysis of expected trends
Wiegmans <i>et al.</i> (2008)	<ul style="list-style-type: none"> • Container terminal operators 	<ul style="list-style-type: none"> • Port physical and technical infrastructure • Geographical location • Port efficiency • Interconnectivity of the port (sailing frequency of deep-sea and feeder shipping services) • Reliability, capacity, frequency and costs of inland transport services by truck, rail and barge (if any). • Quality and costs of auxiliary services such as pilotage, towage, customs, etc. • Efficiency and costs of port management and administration (e.g. port dues). • Availability, quality and costs of logistic value-added activities (e.g. warehousing). • Availability, quality and costs of port community systems. • Port security/safety and environmental profile of the port. • Port reputation (satisfactory ranking in benchmarking studies). 	<ul style="list-style-type: none"> • Interviews • Literature review
Karlaftis <i>et al.</i> (2009)	<ul style="list-style-type: none"> • Shipping company 	<ul style="list-style-type: none"> • Distances between ports • Demand • Supply • Service time 	<ul style="list-style-type: none"> • Modeling

2.4 Summary

The literature review in **subchapter 2.1** starts with giving the definition of innovation, and then the stages of innovation process are defined. Basically, the innovation is defined as a technological or organizational change to the product, service or process which improves the benefit to the consumer of the product. The innovation can apply to the development of both, a product and a process. The main stages of development of an innovation are: (1) the initiation period, (2) development period, and (3) the implementation period.

It can be concluded that any applicable measure for tackling the congestion problem is basically an innovation. It fits the definitions of the innovation, can be categorized under the innovation typologies, and follows the same stages as an innovative process in other fields does.

These definitions are important, because they are used in the systems innovation (SI) approach, which was proposed by Woolthuis *et al.* (2005) for innovation policy design and with modifications will be applied in this research to determine the system success conditions and provide a method for searching innovative success. For understanding the interactions of actors within the system, the model of the National Research and Innovation System is described.

All of this allows gaining a general understanding what is an innovation, how an innovation process develops, what interactions can exist in the process, and how the success of the innovation could be searched for.

The literature review in **subchapter 2.2** describes the main types of the applicable measures for tackling congestion in different situations, including those on port hinterland links. First, the expansion of the existing road infrastructure is looked at. It turns out that due to the phenomenon of latent or induced demand infrastructure expansion is inefficient. This is because of the new vehicle traffic that would not have occurred at all without the capacity increases. This leads to the thought that infrastructure expansion is not only very expensive, but also creates additional traffic.

Second, theories on road pricing are investigated. Those are reviewed, starting from the classics like Smith (1776), through to the development of marginal cost pricing and different variants of second-best pricing. This is to lead to the main result of this and the previous subchapter: Table 3, which presents the impacts of each type of measures and aspects that have to be considered for implementation. It shows that each of the available measures is suitable for a particular type of problem situation, requires certain conditions to be implemented and has certain expected impacts, including certain undesired impacts as well. This generated knowledge should be useful for tailoring a custom solution, which includes a measure or a set of measures, for a particular implementation situation.

An innovation, especially a transport-related one, does not happen in isolation. Many factors exist that have direct or indirect influence on the development and even outcomes of an innovative process. Therefore, in **subchapter 2.3**, keeping the focus on the case study that is investigated in this research, these influencing factors have been reviewed. Those factors include: economic developments, developments in the local, national and supranational

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policies, port traffic evolution, developments in “alternative modes” (rail and inland waterways), changes in competitiveness of the port, changes in energy prices, and others.

Bringing together the knowledge from the two fields (described in 2.1 and 2.2) could bring synergies in a unique way. This could allow developing a methodology that supports the choice of a feasible policy measure and brings it to a successful implementation. The following CHAPTER 3 develops such methodology.

CHAPTER 3 Methodological framework

CHAPTER 1 gives an introduction and defines the scope of this thesis. CHAPTER 2 describes the tools and measures available for tackling the congested port hinterland situation and describes the influencing factors and innovative process.

This chapter describes the developed methodological framework that is used in this research. The methodology consists of three stages.

In the **first stage**, since the outcome of a measure applied differs in each situation, these outcomes should be modeled to determine the results for the concrete situation. The impacts simulation methodology for doing this is described in section 3.1.

In the **second stage** of the methodology the cost-benefit analysis of an innovation process is used. This allows determining the outcomes of the innovation process and evaluating its success.

Last, as the **third stage**, to further contribute to the results of the cost-benefit approach, the Systems Innovation (SI) methodology is used.

In this chapter and the whole thesis the stages of the methodology are presented in a linear way. This makes the methodology and the results comprehensible to the reader. In practice the application of the methodology does not have to be linear. The stages of the methodology could be performed in a different order or simultaneously depending on the case study that is investigated.

The methods used to compose the methodological framework are complimentary; each of them enriches the research results. The impacts simulation allows developing a suitable measure for implementation. The cost-benefit analysis shows what the impacts of this developed measure will be for different groups of the society and predict what their reaction will be to the project. The systems innovation approach contributes further to the research results by providing guidelines for ensuring successful implementation of the developed measure.

3.1 Impacts simulation

The literature review (in section 2.2) presents a range of applicable measures for optimising the use of available road transport infrastructure capacity. In general, the impacts of these measures in theoretical situations are clear. They are listed in Table 3 on page 24.

In practice, however, the results of the theoretical literature review are not applicable, because every situation is different. The impacts of a pricing mechanism can differ in each case, since there are other influencing factors. The characteristics of the designed measure, specific infrastructure network layouts, existence of competing modes, geographical characteristics of an area, different policies and other factors can influence the efficiency and outcomes of an infrastructure optimization measure.

Therefore, for application on concrete infrastructure in a realistic situation, a case-specific investigation is required. In order to determine the concrete impacts of the pricing measures in a specific situation, a structured approach was chosen and it includes the following steps:

- Step 1: selection of impacting factors;
- Step 2: linking selected influencing factors with the freight model used;
- Step 3: analysis using the freight model;
- Step 4: evaluation and interpretation.

Below the steps are described in detail.

3.1.1 Step 1: Selection of impacting factors

In order to select and quantify variables for the step 3 of the impact simulation, the influencing factors that have impact on the case in focus should be detected. In every case those factors will be different, and the impacts they have will differ as well. Here a careful selection should be done. For the problem situation defined in the introduction of this research (see CHAPTER 1, section 1.4) in a typical port hinterland situation, there are several areas that should be looked at.

First are the developments of the port that have to be considered. Those include the dynamics of the port turnover, because the port turnover is shown (see Aronietis *et al.* (2009)) to have impact on the traffic on the road network and other modes of transport. In this context also the investments in the capacity increases and the forecast on port capacity in the foreseeable future need to be considered.

The developments in sea transport should also be taken into consideration. For example, if the European Union decides to support the use of short sea shipping, then impacts can be expected on the hinterland connections of the ports.

The existence of alternative hinterland transport modes in competition with the dominant transport mode is important in the context of this research. As shown in Aronietis *et al.* (2011), often the infrastructure for the possible competing mode does not exist or is underdeveloped in such a way that no mode shift is possible in the short run.

The efforts of national and supranational legislation⁹ and developments in those areas should not be neglected. The legislation sources should be researched and the impacts of the most important policies and legislation taken into account. For example, if the case in focus were to be in the European Union, the researcher should consider the local policies of the region, the federal policies of the country and also the policies of the EU.

When selecting the impacting factors, one should take into account all the aspects that are considered to be important in the case that will be analysed using the freight model. For example, if a certain sector of the economy significantly contributes to the cargo flows on the transport network investigated, the developments in this sector should be taken into account as one of the impacting factors, like it is done with the port turnover in the case investigated to reflect the impact of cargo flows generated by the port. The aspects or conditions in the

⁹ Supranational legislation is a form of international law, based on the limitation of the rights of sovereign countries.

economy which are considered to have little or no impact on the traffic should not be taken into account.

3.1.2 Step 2: Linking factors with the freight model

The previous step gives the general understanding of the impacting factors for the case study in focus. In this step the selected influencing factors should be linked with the variables that exist in the freight model used for determining the impacts of possible measures on hinterland freight transport.

The Freight model Flanders has a set of variables that some specific quantified impacts can be assigned to. Those variables cover a range of topics including economic growth, global trade patterns, demand changes, energy price dynamics, transport policies and port traffic developments. The inputs for those variables should be given in a quantified form.

This step can be accomplished by simply matching the identified factor from step 1 to the corresponding variable in the freight model. For example, the factor reflecting port traffic growth would be linked with employment and import/export variables in the model. The quantification of the inputs is based on a set of assumptions and trusted sources in the literature.

3.1.3 Step 3: Analysis using the freight model

In the third step of impacts simulation the variables have to be fed into the model and the simulations run. Here a purpose-built model could be constructed. But in this research the existing Freight model Flanders is used, because it provides results of a higher quality than the timeframe of a doctoral research allows obtaining with a purpose-built model.

3.1.3.1 The model

The Freight model Flanders¹⁰ is a classic 4-step model and it allows simulating future freight flows, split up by mode (road, rail and inland waterways) and NST-freight category. The model can be used to determine the impact of hypothetical scenarios on future freight transport. It has been developed at the request of public authority (Verkeerscentrum).

The four steps of the model are:

- Generation of flows: this step determines the flows leaving from (or arriving in) zone i (j) in a period. For freight transport this means that for a freight category k it is calculated how many tons are leaving from (arriving in) zone i (j);
- Distribution of flows: the generation of flows serve as input for this stage. The freight flows are determined between zones i and j ;
- Mode choice: which mode is used to move tons from zone i to j ;
- Assignment: this step comprises route choice (after translating the tonnages into number of vehicles in a traffic conversion model).

¹⁰ Commissioned by the “Kenniscentrum Verkeer en Vervoer (afdeling Verkeerscentrum)” and developed by K+P Transport Consultants, Tritel and Mint. In 2011, a change occurred in the composition of the consortium of developers of the strategic Freight model Flanders: Tritel left the consortium, Significance joined and Protrans is the merger of ProTrans and K+P Transport Consultants.

The agreed future infrastructure changes of the Flemish government, like the capacity increase of Albert canal, are taken into account in the model. Transport Logistic Nodes, transfer points where loads change the means of transport simultaneously with a re-consolidation of the shipment, are also included in the model.

For road transport, a distinction is made between traffic on highways and the underlying network, but also between heavy and light vehicles. For inland navigation, six categories of vehicles are used (based on maximum loading capacity). Three types of trains are used: intermodal trains, block trains and single trains. An overview is given in Figure 6¹¹.

Figure 6: Types of vehicles in the model

Mode of transport	Category	
Road	Heavy vehicles	Highway
		Underlying network
	Light vehicles	Highway
		Underlying network
Inland navigation	300 tonnes	
	600 tonnes	
	1350 tonnes	
	2000 tonnes	
	4500 tonnes	
	9000 tonnes	
Rail	Intermodal train	
	Block train	
	Single train	

Source: Markianidou *et al.* (2012)

A detailed description of the Freight model Flanders is available in Markianidou *et al.* (2012).

3.1.3.2 Scenarios

For the research purposes a set of scenarios has to be tailored to construct a min-max range. Each scenario should be a combination of several assumptions: economic, on policy, import and export, competing modes, port turnover and developments. The scenarios should aim at reflecting realistic future developments in the economy, but also take into account the limitations of the model.

The set of scenarios constructed should enable testing the propositions 3 and 4 of the research. Within the scenarios, a reference scenario should be constructed. A reference scenario is a “business as usual” situation where no policy measures are taken in addition to those already in place. It can then be used for comparing the reference scenario to other scenarios for a year in the future.

¹¹ The tonnages in Figure 6 refer to the maximum load of the vehicle, not to the average load.

3.1.4 Step 4: Evaluation and interpretation

To understand the impacts of the scenarios on the motorway network an analysis of the results is performed. This is done at three levels.

In the **first level** the tonnages of cargo traffic passing specific locations on the road network and growth figures for every scenario are calculated. The output refers to specific points on the motorway grid and hence variations in the results between scenarios might be interpreted as shifts between the modes and/or route changes. These effects can be triggered by some of the policies which were incorporated in the scenarios.

At the **second level**, route change investigation is done by use of the difference plot, an illustration tool of the Cube software. The purpose is to benchmark the different scenarios against the reference scenario. This is done by drawing the impacts of the different scenarios in both colour and thickness on the road network to show whether an increase or decrease of cargo traffic has taken place.

For the **third level** of investigation a mode shift investigation is done. Specific regions are selected to analyze the mode shift effects of the scenarios. For each region, the total incoming and outgoing flows in tonnes are calculated for road, rail and inland waterways transport.

The quantitative results obtained are only meant to provide overall trends for the case study investigated.

It must be taken into account that passenger traffic is not incorporated in the model. Therefore, the interactions that the modelled scenarios would have with passenger traffic are not calculated. If a scenario tested would create a reduction of freight traffic, passenger traffic would react to this change like it does in the case of expansion of infrastructure capacity. This is described in the literature review section 2.2.1.1 on latent/induced demand.

The outputs of the modeling should allow selecting a specific case study for detailed investigation in this research. The case study should be suitable for practical implementation and amongst the tested scenarios tackling the congestion on port hinterland links.

3.1.4.1 Outputs of the model as inputs for cost-benefit analysis

The version of the model used for this research provides outputs of the calculations of the scenarios as tonnage matrix. An example is provided in Table 5. In the freight model there are 144 zones.

Table 5: Example of a tonnage matrix

		Incoming flows						
		Zone 1	Zone 2	Zone 3	Zone 4	Zone n
Outgoing flows	Zone 1							
	Zone 2							
	Zone 3							
	Zone 4							
	...							
	...							
	Zone n							

For obtaining the results of simulations in tonkilometres, each element of the matrix is multiplied with the distance between the zones. This allows obtaining tonkilometre matrixes usable as inputs for the cost-benefit analysis.

The obtained tonkilometre matrixes for the scenario runs contain information on the impacts of each scenario on the cargo flows. In the cost-benefit analysis, those are used for calculating the costs and benefits for the society from the measure tested in the scenario.

3.2 Cost-benefit analysis of innovative process

3.2.1 The innovator

The innovator is an entity that takes the leading role in the innovation process. Two different types of innovators can be distinguished. First is the **private innovator**, which is a private company or a consortium of private companies. The second is the **public innovator**, which is the government itself, a governmental institution or agency, or a sort of consortium, possibly with involvement of private partners as well.

To make the distinction clear between those two, it is assumed that the private innovator aims at increasing private benefit as the result of the innovation. The public innovator aims at increasing the benefit to society.

3.2.2 Characteristics of an innovation

Introduction of an innovation is always associated with costs and benefits. The innovator faces costs that are related to the development and introduction of the innovation and enjoys the benefits that the innovation brings. The society as well is impacted by the innovation and faces certain costs and benefits. Some costs and benefits are common for the innovator and the society.

Based on Arduino *et al.* (2010a), there are two possible views on this:

- Industrial-economic point of view (from the perspective of innovator);
- Welfare-economic point of view (from the perspective of society).

Industrial-economic point of view

For an innovative actor (e.g. company) the following can be defined:

- R_p - private revenues (before innovation);
 - C_p - private cost (before innovation);
- and logically:
- ΔR_p - change in private revenues as a result of innovation;
 - ΔC_p - change in private costs as a result of innovation.

The following equation shows the impacts of the innovation for the innovator:

$$\Delta R_p - \Delta C_p .$$

As a result of innovation, an innovating actor will face some additional costs ΔC_p . The revenues will increase by ΔR_p during the lifespan of the new product as a result of the increased value of it to the customer.

In this situation, the innovation will initiate only if the increase in costs of innovating are justified by the increased final product value that the customer is willing to pay for.

Welfare-economic point of view

From the welfare-economic point of view, which analyses social welfare (for society), the following can be defined:

- B_s - social benefit (before innovation);
- C_s - social cost (before innovation);

and logically:

- ΔB_s - change in social benefit as a result of innovation;
- ΔC_s - change in social cost as a result of innovation.

This equation shows the impacts of the innovation for the society:

$$\Delta B_s - \Delta C_s.$$

3.2.3 Possible situations

In practice, depending on who the innovating actor is, and what the values of the impacting factors are, different situations are possible. Table 6 summarizes those possible situations.

The different actors from the table should be explained. A “public innovator” is the government itself that develops the innovation directly. In cases where a separate government body, a company established by the government, a private company under a concession agreement, or a public-private partnership consortium is developing an innovation, it is considered a “public innovator (with private character)”. A “private innovator” is a private entity without any public interest.

Table 6: Possible situations

Public innovator	Public innovator (with private character)	Private innovator
<p><i>Situation a.1</i> $\Delta B_s - \Delta C_s < y$ In this situation with public innovator the industrial-economic profits are not considered, but welfare-economic benefits are below threshold y.</p> <p>Innovation will fail.</p>	<p><i>Situation b.1</i> $\begin{cases} \Delta R_p - \Delta C_p > x \\ \Delta B_s - \Delta C_s < y \end{cases}$ In this situation the industrial-economic profits exceed a certain threshold x and welfare-economic benefits stay below threshold y.</p> <p>The government might stop the innovation as soon as it is clear that the social benefit from its introduction is below the required threshold y. The innovator will want to proceed with innovation. But opposition from the actors bearing the cost ΔC_s and gaining little benefits ΔB_s is expected.</p>	<p><i>Situation c.1</i> $\begin{cases} \Delta R_p - \Delta C_p > x \\ \Delta B_s - \Delta C_s < y \end{cases}$ In this situation the industrial-economic profits exceed a certain threshold x and welfare-economic benefits stay below threshold y.</p> <p>The innovator will want to proceed with innovation. But opposition from society is possible and actions from government will follow to stop the innovation if the impacts to the society are too negative. Possibly, the society would be ready to accept compensation S_s from the innovator to cover those negative impacts. If this or other barriers do not exist, the innovation is likely to succeed.</p>
	<p><i>Situation b.2</i> $\begin{cases} \Delta R_p - \Delta C_p < x \\ \Delta B_s - \Delta C_s < y \end{cases}$ In this situation the industrial-economic profits and welfare-economic benefits are below thresholds x and y. Innovation will fail.</p>	<p><i>Situation c.2</i> $\begin{cases} \Delta R_p - \Delta C_p < x \\ \Delta B_s - \Delta C_s < y \end{cases}$ In this situation the industrial-economic profits and welfare-economic benefits are below thresholds x and y. Innovation will fail.</p>

Public innovator	Public innovator (with private character)	Private innovator
<p><i>Situation a.2</i> $\Delta B_s - \Delta C_s > y$ In this situation with public innovator the industrial-economic profits are not considered, but welfare-economic benefits are above threshold y.</p> <p>Innovation is likely to succeed, unless a barrier exists.</p>	<p><i>Situation b.3</i> $\begin{cases} \Delta R_p - \Delta C_p < x \\ \Delta B_s - \Delta C_s > y \end{cases}$ In this situation sufficient industrial-economic profits do not arise from the introduction of the innovation, but welfare-economic surplus generated is above a threshold y.</p> <p>Since the government is involved, subsidies S_p could be provided to cover the costs of the innovation. This could happen if there is sufficient support for providing subsidy and net benefit of the project is higher than in other projects that government can invest in. Then the innovation will succeed, unless a barrier exists.</p>	<p><i>Situation c.3</i> $\begin{cases} \Delta R_p - \Delta C_p < x \\ \Delta B_s - \Delta C_s > y \end{cases}$ In this situation with a private innovator sufficient industrial-economic profits do not arise from introduction of the innovation, but welfare-economic surplus generated is above a threshold y.</p> <p>Innovation will fail, unless the introduction of the innovation is important enough to the society to make the government pay subsidies S_p to the innovator and no barrier exists.</p>
	<p><i>Situation b.4</i> $\begin{cases} \Delta R_p - \Delta C_p > x \\ \Delta B_s - \Delta C_s > y \end{cases}$ In this situation the industrial-economic profits and welfare-economic benefits are above thresholds x and y. The innovation is likely to succeed, unless a barrier exists.</p>	<p><i>Situation c.4</i> $\begin{cases} \Delta R_p - \Delta C_p > x \\ \Delta B_s - \Delta C_s > y \end{cases}$ In this situation, like in 3.a, the industrial-economic profits and welfare-economic benefits are above thresholds x and y. The innovation is likely to succeed, unless a barrier exists.</p>

3.2.4 Characteristics of exogenous factors to innovation: subsidies and barriers

Other exogenous factors related to the introduction of an innovation exist. First are the subsidies, which are payments that can be given by the government to support the innovation. Second are the barriers, which are reasons for the innovation to fail.

Subsidies are payments or other benefits that are presented to the innovation actors by another party to cover the costs (partly or fully) related to the innovation process and make it successful. For example, subsidies S_p can be given by a government to support the introduction of an innovation that brings important benefits to society. Or compensation S_s could be paid by the innovator to society to compensate for externalities inflicted.

Barriers are non-monetary obstacles that an innovation can face. For example, a barrier can be the unwillingness of an important decision maker or a politician in power to agree to introduction of the innovation or a certain part of it.

3.2.5 Success of an innovation

As such the characteristics of a proposed measure are described, including economic impacts and exogenous factors. The logical relationships can be derived to describe the success of an innovation.

For an innovation to succeed, in general, the following relations should be true:

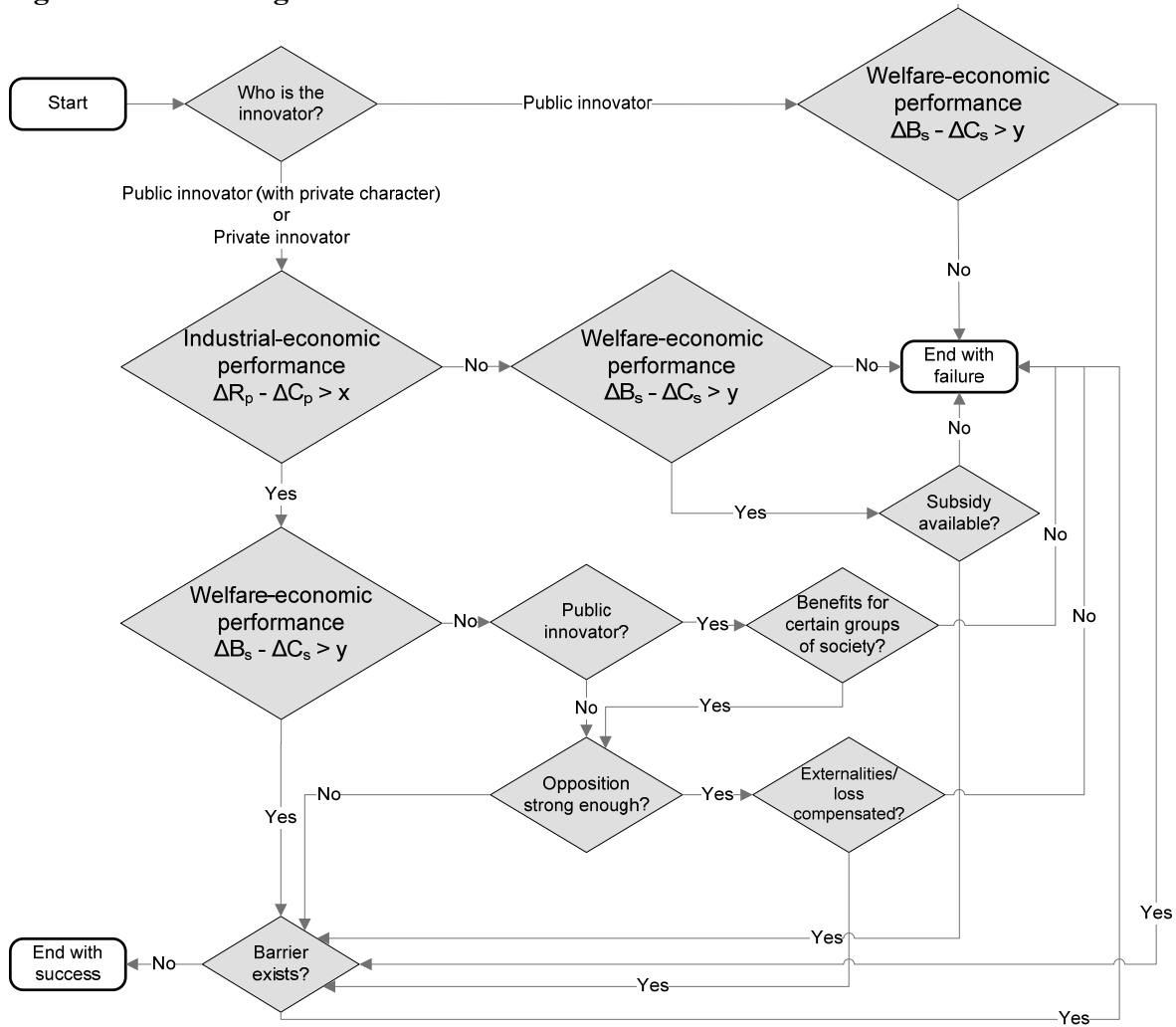
$$\begin{cases} \Delta R_p - \Delta C_p + S_p > x \\ \Delta B_s - \Delta C_s + S_s > y \end{cases}$$

Here x and y are threshold values that a private or public innovation actor requires in order to continue the innovation process, or to stop the innovation process. If x or y are too small, the innovator or society will stop the innovation process and innovation will fail. For example, a private innovator will not proceed with innovation if it does not ensure certain returns (at least x or more), which he considers sufficient. For society, the impacts of an innovation should be higher than a certain value y. Those values will be different for each situation.

3.2.6 Success algorithm

The success algorithm shown in Figure 7 describes the path that an innovation will follow under different economic conditions. The solution path for any possible innovation situation from Table 6 is shown graphically with the success algorithm.

Figure 7: Success algorithm



3.2.7 Evaluation of an innovation

The algorithm shown above can be used in practice for testing the success or failure of innovations. This can be done before their implementation to determine the possibility of their success. In this research it is done for the case of introducing road pricing in Belgium and described in subchapter 5.1.

First, the relevant data that characterize the innovation have to be gathered. It includes the data characterizing the private revenues of the innovator ΔR_p , the private costs of innovating ΔC_p , the social benefits that arise from innovation ΔB_s , and the social costs (or externalities inflicted) that are linked to the innovation ΔC_s .

When quantifying those cost and benefit components, they should be split into basic cost categories. There are the initial investment costs, which are required to start the project, the yearly operation and maintenance costs, the yearly benefits throughout the lifecycle of the project, and the costs of capital through time, which are related to the spread of the revenues ΔR_p , benefits ΔB_s , costs ΔC_p and externalities ΔC_s over time.

The European Commission uses as performance indicators for cost-benefit analysis the net present value (NPV), the internal rate of return (IRR) and the Benefit-Cost ratio. To calculate NPV, the use of an exponential discounting model and 5% European social discount rate is suggested.¹²

Having the data allows inserting them in the equation that defines the success of an innovation:

$$\begin{cases} \Delta R_p - \Delta C_p + S_p > x \\ \Delta B_s - \Delta C_s + S_s > y \end{cases}$$

One would then be able to see whether the success conditions are met and whether subsidies might be required for the success of the innovation.

In a situation where the success conditions are met, a check for barriers should be done (as shown by the success algorithm) to make sure that failure of the innovation is not caused by a barrier.

3.3 Systems Innovation analysis

In the previous stage of the methodology the cost-benefit approach was used. The use of this approach requires quantified data, but, unfortunately, for future projects the availability of such data is often a problem.

Therefore, as the third stage of the methodology, use of Systems Innovation (SI) approach is proposed. It allows working on innovation cases where there is lack of quantifiable data. The approach is chosen, because it provides useful outputs, like the practical suggestions for actions in areas which the innovator should target to ensure the success of the innovation. The inputs that the approach needs are qualitative and require studying a range of innovation cases.

The SI approach is not meant to replace the cost-benefit approach, but to complement it by providing additional results, which are valuable for policy makers in practice.

3.3.1 Application of the Systems Innovation approach¹³

The SI approach to analysing the causes of success or failure of innovation is used in this research. The systems involved are defined in terms of the various actors, in the sub-sectors concerned, together with a broadly defined 'institutional' environment which captures all of the relevant influences on the innovation process.

The SI approach is applied in two steps. First, several cases are analysed. Second, the results of the analysis are applied to the case of introduction of road pricing on the Belgian road network, which is in the focus of this research.

¹² Cruz Rambaud and Munoz Torrecillas (2006)

¹³ Adopted with modifications from InnoSuTra project deliverable D6, Arduino *et al.* (2011b).

The approach to be used, which owes a great deal to the SI approach as modified by Woolthuis *et al.* (2005), will be applied to four individual cases, which have been selected for this purpose, as the first step:

- Case 1 – EU International road transport market liberalization: cabotage;
- Case 2 – Eurovignette directive;
- Case 3 – Introduction of three loaded trips limit in the ECMT multilateral road transport permit system;
- Case 4 – Variable speed limits.

Investigation results from 19 other cases are used. From all 23 cases 9 can be considered “successful”, 8 are “failure or not-yet-successful” and the other 6 are “intermediate”. The cases were selected in the domain of surface transportation based on a long list of possible cases to be investigated. The selection was done at a consultation event¹⁴ that hosted a large number of invited experts. The goal was to select characteristic success and failure cases.

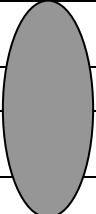
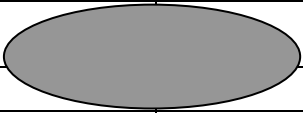

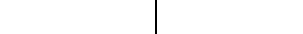

Based on Woolthuis *et al.* (2005) approach the SI analysis is split into three separate temporal phases: initiation, development and implementation.

The overall aim is first to identify where the conditions for successful innovation transfer are not met (this may be one or more conditions) and then to identify the key innovation variables to be addressed, with which the actors may best be stimulated by policy intervention to ensure that the appropriate success conditions can be met.

Figure 8 shows a summary of the various elements of the SI policy framework. The actors are shown across the framework as columns and the institutional environment as rows which will interact with the actors. The actors here are structured to include, under generic headings, those relevant to the innovation case. Government bodies are specifically excluded as the aim is to identify in the matrix the areas of interaction between actors and the institutional environment available for intervention by public policy.

The SI analysis indicates which actions, between actors and the institutional environment, are required to establish the success conditions (shown in Figure 8 with shading; for illustration only) and the area where actions would not achieve the success conditions (shown in Figure 8 without shading).

Figure 8: Example of Systems Innovation matrix

	Knowledge Institutes	Standard Bodies	Initiator/ Entrepreneur	Developers/ Industry	Transport Operators	Third parties, Lobbyists, Unions
Infrastructure <i>Ports, etc.</i>						
Institutional <i>Hard: Laws, regulations</i>						
Institutional <i>Soft: norms, values</i>						
Interaction <i>Weak network</i>						
Interaction <i>Strong network</i>						
Capabilities						

¹⁴ InnoSuTra project consultation event took place on 13 April 2010 in Antwerp. For details see Arduino *et al.* (2010b).

In analysing the system success conditions it is important to note that those will be identified principally in the area of the institutional environment. Only if essential actors/organisations are missing will this absence lead to systemic failure, e.g. the absence of a key applied research institute. In general, the outcomes of actors' actions will be part of the institutional environment. It is important to recognise the wide and general nature of the institutional environment – including the overall socio-economic context – even though, in the SI approach, it is to show how the institutional environment stimulates innovation and permits it to take place efficiently.

In detail, the structure of the institutional environment is the following:

1. Infrastructural success conditions

The presence of adequate transport and communications infrastructure is an important pre-requisite for the success of a number of transport innovations. This is perhaps particularly true in the case of rail networks and their inter-operability across national boundaries, as well as ports and port hinterlands.

2. Institutional success conditions

The presence of relevant institutional outcomes is a key factor in determining the success of the innovation process. The outcomes which have so far been discussed have been classified as positive factors or barriers. This poses no problem as barriers may readily be expressed in terms of their obverse, i.e. the absence of the relevant success conditions. The institutional factors are generally, in the SI literature, separated into hard institutional factors and soft institutional factors.

2.1 Hard Institutional Rules

The main areas here are the formal ones of:

- the general legal system relating to contracts, including company law, employment contracts, and legal rules relating to IPR and patents
- the area of standards, including technical standards, health and safety standards, and accounting standards

Woolthuis *et al.* (2005) includes corporate governance in the grouping of hard institutional rules, but such governance seems more suitable to be defined as a soft institutional factor, as indicated below.

2.2 Soft Institutional Rules

The main areas covered under this heading are those which relate to the political, economic, business, entrepreneurial, and cultural influences and values, which shape the context in which innovation takes place and the objectives of public policy. These will include, inter alia, firms' willingness to cooperate on innovation; the level of risk aversion in the society, and the overall commitment of government and private parties to support innovation. This area covers two important factors, which are not always covered under the heading of soft institutional factors. These are: corporate governance, which will include the decisions made by finance departments in firms on the level of the internal rate of return on innovation investment and the accompanying pay-back period, and the activities of lobbying groups, both intra-industry (e.g. freight forwarders) and extra-industry (e.g. Greenpeace).

3. Interaction success conditions

It is in this area where the SI approach most clearly involves a rejection of the atomistic market structures which dominate neo-classical economic thinking and attribute all innovation failures to market failure. Instead, the SI approach stresses the cooperative interactions within firms, between firms, and with other actors within the

overall political economic system. It is the efficiency or otherwise of this network system, which determines the success of innovations, including their spread across sectors. It is now accepted in the SI literature that there are two types of system/network interaction: strong interactions and weak interactions. Paradoxically, both types of interactions may lead to system failure and the conditions for success not manifesting.

3.1 Weak Network Issues

Problems in this area are relatively easy to discern as they will be manifested in the inability for learning to take place between actors and for this absence of network ties may lead to firms' inability to adapt to new technological developments. Overall in the sector concerned there will be no shared vision of future technological developments and no coordination of research efforts and investment (Carlsson and Jacobsson (1997)).

3.2 Strong Network Issues

Strong network problems appear to be a contradiction in terms. However, strong networks can provoke their own problems. There are a number of aspects of strong networks that can be dysfunctional. These are:

- Where strong network actors are guided in the wrong direction by other actors and away from important sources of technology know-how (Carlsson and Jacobsson (1997)).
- Group myopia where the network becomes internally focused and other inputs are rejected (Bogenrieder and Nooteboom (2001))
- Dependence on dominant partners, either economically or technologically (e.g. Williamson (1985))
- Absence of complementary weak ties (outside the strong network) to those in other industries, etc. who can provide up to date information and knowledge on new technologies, etc. (Granovetter (1983); Burt (1987)).

4. Capabilities

This category of success conditions relates to the capacities which firms may or may not have. The capabilities involved may be technological, financial, human resource, or cultural. In all cases this capability, if missing, may prevent the company from making the leap from old to a new technology or paradigm (Smith (2000)). Conversely, the presence of such capabilities will enable a firm to take up the challenge of being able to move outside the confines of its existing market profile.

Interactions within the SI matrix (see Figure 8) may have a positive or negative impact on the evolution of innovation. Positive interactions are depicted with shaded ellipse, while negative interactions or areas with identified deficiency are depicted with outlined ellipse. This is a graphical representation. The combinations (Actors – Actors, Actors – Institutions, Institutions – Institutions) of positive and negative interactions are also reported separately in the conclusions of each case analysis.

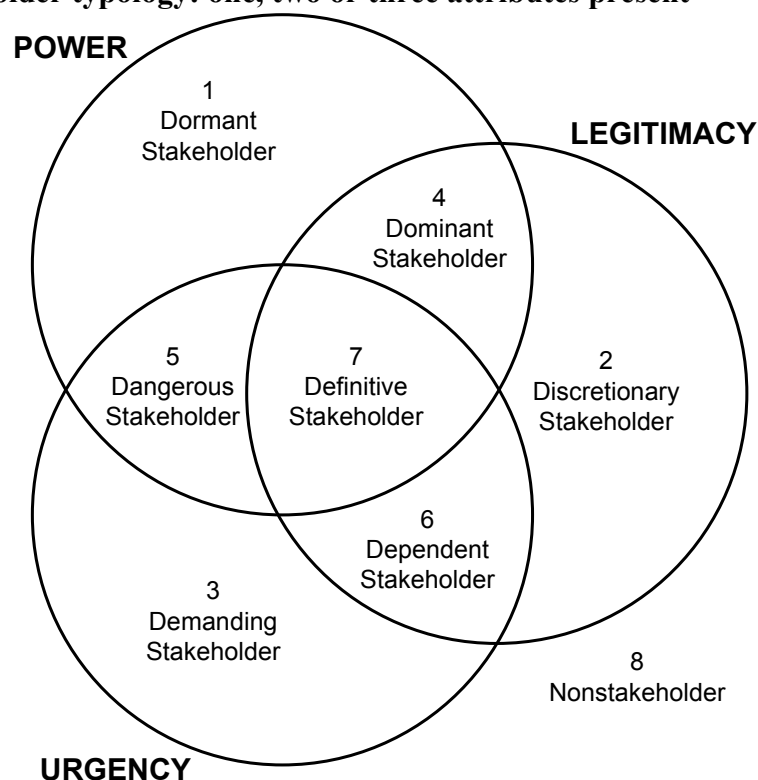
The conclusions include a discussion on the impact (or the lack of) policy intervention had on the evolution of each investigated case, as well as an estimate of alternative proposed policy interventions. As the second step, those conclusions from all the investigated cases are used for the application of SI analysis to the case study of introduction of road pricing on the Belgian road network.

3.3.2 Framework for action

To take the SI approach a step further, based on management theories (section 2.1.6), a framework for action is developed for the case study investigated. The approach proposed by Mitchell *et al.* (1997), which allows assessing which stakeholders require the attention of the innovator, is used here. It is based on three attributes: the power to influence, the legitimacy of each stakeholder's relationship with the organization, and the urgency of the stakeholder's claim on the organization. These components form salience classes of the stakeholders which are shown graphically in Figure 9.

The low salience classes (areas 1, 2, and 3) are called "latent" stakeholders and are identified by their possession or attributed possession of only one of the attributes. The moderately salient stakeholders (areas 4, 5, and 6) are identified by their possession or attributed possession of two of the attributes, and because they are stakeholders who "expect something," Mitchell *et al.* (1997) call them "expectant" stakeholders. The combination of all three attributes (including the dynamic relations among them) is the defining feature of highly salient stakeholders (area 7).

Figure 9: Stakeholder typology: one, two or three attributes present



Source: Mitchell *et al.* (1997)

In this research the stakeholders from the case study investigated are categorized according to the presence or perceived presence of these three attributes. This allows assigning a salience class to the stakeholders and is used to determine the priority of a stakeholder for managerial attention.

Based on neo-institutionalism theory (section 2.1.6.2), which argues that including societally legitimated elements in their formal structures maximize their success, the main interests of stakeholders for the case study investigated are identified. Actions are suggested in line with

principles of institutional entrepreneurship theory (section 2.1.6.3), attaching the suggested actions to pre-existing organizational routines where possible and reaffirming their alignment with important stakeholder values.

CHAPTER 4 Impacts simulation¹⁵

The increased port goods traffic turnover growth has impacts on the traffic levels on the hinterland links of the ports – it leads to congestion at certain times of the day on certain points of the transport network. This is a common phenomenon and can be observed around many ports, usually on the road network.

The impacts of congestion are costly, especially in the context of freight transport. The negative impacts of congestion on port hinterland links include increased costs related to time, uncertainty about arrival times, waste of fuel, increased pollution, increased wear of vehicles used and other negative effects. The increased costs reduce competitiveness of the port facing congestion.

The literature, as described in CHAPTER 2, proposes a range of applicable measures for dealing with the congestion problem, including measures that could be applied in port hinterland situations. Those include different marginal cost, second best, facility-based, distance-based pricing and zonal pricing schemes, as well as infrastructure and regulatory measures. The impacts of those instruments are known and have been summarized in subsection 2.2.3 (Table 3 on page 24) of this thesis.

If implemented, those instruments are efficient. However, in practice the problem is that the implementation almost always faces strong opposition from the public or some interest groups. Therefore in practice the implementation is hard or even impossible.

This research proposes a solution to this problem, because literature sources do not target the practical implementation of these applicable measures for tackling congestion on port hinterland links. But practical implementation is important for any result being achieved at all.

The methodology proposed, tackles this problem with a three-stage approach. In the first stage, since the outcomes of a measure applied differ in each situation, these outcomes are modelled to determine the results for the concrete situation. Here, the case study for further research is selected. In the second stage of the methodology the cost-benefit analysis of an innovation process is used. This allows determining the outcomes of the innovation process and evaluating its success. Last, in the third stage, to further contribute to the results of the cost-benefit approach, the Systems Innovation (SI) methodology is used. This is a way of bridging the gap between the literature which develops possible infrastructure use optimization measures and literature which analyses the success conditions of innovations. The application of the methodology is done with the help of the case study of a realistic scenario of implementation of road pricing in Belgium, described in subchapter 5.1.

This CHAPTER 4 and the next two chapters (CHAPTER 5 and CHAPTER 6) present the analysis performed in three blocks according to the methodology developed previously. First, the impacts simulation of the possible infrastructure pricing measures is described in CHAPTER 4. Then, in CHAPTER 5 and CHAPTER 6 the cost-benefit and SI approach is applied to the chosen case study.

¹⁵ This chapter has been adopted with modifications from E313 project deliverable, Aronietis *et al.* (2009).

4.1 Linking factors with the freight model

The step 1 of the methodology was completed in CHAPTER 2. As step 2 of the methodology, here a link is made between the research in the previous chapters and the Freight model Flanders.

The Freight model Flanders is used to determine the effects of possible scenarios on freight transport. Details of the scenarios used are described in the following sub-chapter.

It is important to note that in the freight model the so-called agreed infrastructure changes (“Iopende programma”) of the Flemish government are taken into account. More specifically, the following infrastructure changes have been taken into account:

- the Oosterweel connection¹⁶;
- AX connection N49-N31;
- Liefkenshoek rail tunnel;
- Seine-Scheldt connection;
- Albert canal capacity increase.

Table 7 summarises the subsections of the literature review chapter 2.3 by isolating the key topics identified as most relevant in the different research blocks. The third column presents a selection of the quantified variables available in the freight model for each of the aforementioned topics. Some variables have been selected for a sensitivity analysis. That means that the selected variable will be assigned several values in the scenarios in order to quantify the effects.

¹⁶ The assumption is made that freight trucks are not allowed anymore in the Kennedy Tunnel in 2020.

Table 7: Variables and scenarios

Literature review section	Topic	Related CUBE Variable (selection)	Selected for sensitivity analysis
2.3.1	Economic growth / GDP growth / Income per capita	AAGR employment per NACE-category AAGR employment per region per NACE-category AAGR of the household consumption in value AAGR of the GDP per country (Belgium) AAGR of the household consumption in value	X X X
2.3.1	Changes in demand taste / trends		
2.3.1	Production and distribution patterns		
2.3.1	Global trade / trade patterns	AAGR of value per NST category, export AAGR of value per NST category, import AAGR of the GDP per country (Belgium)	X X X
2.3.1	Globalization	AAGR of value per NST category, export AAGR of value per NST category, import AAGR of the GDP per country (Belgium)	X X X
2.3.1	Demographic changes	AAGR National population AAGR population per Belgian region	
2.3.1	Labour market	AAGR employment per NACE-category AAGR employment per region per NACE-category	X X
2.3.1	Energy and oil prices	Road: kilometer costs highway (absolute values) Road: kilometer costs other (absolute values) Road: percentage of evolution of the kilometer cost (fuel, tires, maintenance) Road: percentage of evolution of the cost per hour (salaries, fees) Road: percentage of evolution of the cost per day (vehicle cost, insurance, structural fees) Rail: percentage of the evolution of prices Inland waterways: percentage of evolution of the prices Road, rail, inland waterways: absolute change of price per tonkilometer	X
2.3.1; 2.2.3 2.3.5 2.3.1; 2.3.2; 2.3.5; 2.3.4; 2.2.3	Environmental Policy and pricing externalities EU legislation – political goals Infrastructure policy and developments / Quality of transport services	Road: kilometer costs highway (absolute values) Road: kilometer costs other (absolute values) Road: percentage of evolution of the kilometer cost (fuel, tires, maintenance)	X

Literature review section	Topic	Related CUBE Variable (selection)	Selected for sensitivity analysis
2.3.1; 2.3.5; 2.3.4; 2.2.3 2.3.5 2.3.5	Policy measures Logistics action plan Regulatory issues	Road: percentage of evolution of the cost per hour (salaries, fees) Road: percentage of evolution of the cost per day (vehicle cost, insurance, structural fees) Rail: percentage of the evolution of prices Inland waterways: percentage of evolution of the prices Road, rail, inland waterways: absolute change of price per tonkilometer Average load per type of truck, per distance class, per NST-category Empty trucks factor Ratio tonnes large trucks/tonnes small trucks (per distance class, per type of truck, per nst)	X X
2.3.5; 2.2.3 2.2.3	Road pricing E313 traffic	Road: kilometer costs highway (absolute values) Road: kilometer costs other (absolute values) Road: percentage of evolution of the kilometer cost (fuel, tires, maintenance) Road, rail, inland waterways: absolute change of price per tonkilometer Average load per type of truck, per distance class, per NST-category Empty trucks factor Ratio tonnes large trucks/tonnes small trucks (per distance class, per type of truck, per nst)	X X
2.3.2	Port traffic	AAGR employment per region per NACE-category Domestic Import/Export flows (per NST category)	X X
2.3.3	Albert Canal traffic	Inland waterways: percentage of evolution of the prices	X
2.3.1	Technological developments including transport and fuel technology	Average load per type of truck, per distance class, per NST-category Empty trucks factor Ratio tonnes large trucks/tonnes small trucks (per distance class, per type of truck, per nst)	

Literature review section	Topic	Related CUBE Variable (selection)	Selected for sensitivity analysis
2.3.1; 2.3.5	Geopolitical situation	-	
2.3.1; 2.3.5	Security matters	-	
2.3.1	Urban development	-	
2.3.5	Impact of SSS	-	
2.3.5	TEN-T	Features of the infrastructure (e.g. speed, capacity,...)	
2.3.1	Social implications	-	
2.3.4	Iron Rhine traffic	Rail: percentage of the evolution of prices	X

Source: Aronietis *et al.* (2009)

4.2 Scenario building

As step 3 of the methodology, the calculations and analysis is done with the help of the freight model. Several scenarios have been built to construct a range of possible situations (see Table 8). Each scenario is a combination of several assumptions: economic assumptions, policy assumptions, assumptions of population and household consumption, assumptions of import and export (expressed in value), assumptions of inland navigation and port assumptions.

Table 8: Scenarios

	Economic Assumptions; assumptions import and export	Policy assumptions	Assumptions inland navigation	Port assumptions
Scenario 1	Low growth	Continuation of current policy	Continuation of current policy	Following economic assumptions
Scenario 2	Low growth	Continuation of current policy	Extra measure inland navigation	Following economic assumptions
Reference scenario	Normal growth	Continuation of current policy	Continuation of current policy	Following economic assumptions
Scenario 3	Normal growth	Continuation of current policy	Extra measure inland navigation	Following economic assumptions
Scenario 4	Normal growth	Moderate transport policy	Continuation of current policy	Following economic assumptions
Scenario 5	Normal growth	Moderate transport policy	Extra measure inland navigation	Following economic assumptions
Scenario 6	High growth	Moderate transport policy	Continuation of current policy	Following economic assumptions
Scenario 7	High growth	Moderate transport policy	Extra measure inland navigation	Following economic assumptions
Scenario 8	Normal growth	Internalizing external costs of all modes	Continuation of current policy	Following economic assumptions
Scenario 9	Normal growth	Continuation of current policy	Continuation of current policy	0.5 x results economic assumptions
Scenario 10	Normal growth	Continuation of current policy	Continuation of current policy	1.5 x results economic assumptions
Scenario 11	Normal growth	Internalizing external costs of all modes	Continuation of current policy	0.5 x results economic assumptions
Scenario 12	Normal growth	Internalizing external costs of all modes	Continuation of current policy	1.5 x results economic assumptions

Source: Aronietis *et al.* (2009)

4.2.1 Scenario assumptions

Economic, import and export assumptions

Economic assumptions

Economic growth will lead to an increase in transport (principle of derived demand). As such, different assumptions of economic growth will lead to different consequences for freight transport.

In the literature several sources can be consulted stating assumptions about future economic growth. In *European Energy and Transport Trends to 2030 – update 2005* (European

Commission (2006)), a yearly economic growth of 2% until 2020 in Belgium has been forecasted. This economic growth represents the yearly evolution of the Gross Domestic Product (GDP) in real terms (adjusted for inflation). This leads to three economic assumptions in this research project:

- Economic assumption 1: low growth
- Economic assumption 2: normal growth
- Economic assumption 3: high growth

The economic assumptions can be expressed as follows:

- Economic assumption 1: growth GDP – 0.5% = 1.5%
- Economic assumption 2: growth GDP = 2%
- Economic assumption 3: growth GDP + 0.5% = 2.5%

Economic growth is not being used directly in the Freight model Flanders to determine the incoming and outgoing flows for the Belgian regions (generation of flows in the 4-step model). Instead, employment per region is used.

In relation to foreign zones, the evolution of GDP is actually used. It is also referred to the report of the European Commission (2006), see Table 9.

Table 9: Expected yearly growth of the GDP in % per country or region

<i>Country/Region</i>	<i>Normal growth</i>	<i>Low growth</i>	<i>High growth</i>
Netherlands	1.6	1.1	2.1
France	2.0	1.5	2.5
Germany	1.4	0.9	1.9
United Kingdom	2.5	2.0	3.0
Italy	1.6	1.1	2.1
Iberian Peninsula	2.4	1.9	2.9
Rest EU	2.2	1.7	2.7
Rest world	3.0	2.5	3.5

Source: Aronietis *et al.* (2009) based on European Commission (2006), except “rest world”

Federaal Planbureau (2008) indicates a yearly, estimated growth of employment of 0.9% in the period 2008-2013. The following assumptions for the Belgian regions are set up:

- **Low growth:** growth employment – 0.239% = 0.717%
- **Normal growth:** growth employment = 0.956%
- **High growth:** growth employment + 0.239% = 1.195%

The growth of GDP for foreign regions is based on Table 9.

Assumptions import and export (expressed in value)

The growth of the import and export flows in value also serves as an explaining variable in the freight model. Based on Federaal Planbureau (2008) it is assumed that the import and export flows will rise by 4.3% yearly when there is a “Normal Growth” in the economic assumptions: “Normal assumptions import and export”. If economic assumptions indicate a “Low Growth”, it is assumed that the import and export flows will rise by 3.8%: “Low assumptions import and export”. In case of “High Growth” in the economic assumptions, import and export flows will rise by 4.8%: “High assumptions import and export”.

Policy assumptions

A distinction is made between:

- **Continuation of current policy;**
- **Moderate transport policy;**
- **Internalizing external costs of all modes (road, rail and inland waterways).**

Continuation of current policy

In the assumption of “continuation of current policy” a growth of the costs of road transport and rail transport is assumed of 0.1% per year. A growth of the costs of road transport is considered as probable given the far advanced deregulation of the road freight transport sector. For the rail freight transport one assumes the persistent dominance of national railway companies. A deregulation leads to a reduction of national subsidies and will cause an upwards pressure on the prices (NEA Transport research and training and Universiteit Antwerpen (2007)). These growth percentages should be seen as relative percentages. In other words, road transport and rail transport will have a slightly bigger cost increase compared to inland navigation. In this analysis it is not necessary to look up the actual growth percentages. Growth percentages respecting the relative position between the modes are enough.

Moderate transport policy

The moderate transport policy starts with the assumptions from the “Continuation of current policy” and adds the following costs for road and rail. The values mentioned in this text refer to NEA Transport research and training and Universiteit Antwerpen (2007).

For road, a road pricing scenario is introduced. The amount is set to be 0.15 € per kilometre in the Benelux, which is applied on the highways. This cost per kilometre will replace the “verkeersbelasting” and “Euro-vignette”. On the non-highways, this value is set to be 0 € per kilometre¹⁷. The amount chosen is based on German LKW-Maut toll rate per kilometre, because of high likelihood that a comparable amount would be chosen in real life implementation.

For rail, it is assumed that a higher user charge (“gebruikersvergoeding”) will be introduced. In 2007, a user charge of 1.63 € per train-km is reported. This value could be set to 3.30 € in the future. Therefore, it is suggested to add in this assumption an extra value of 1.67 € per train-km in the model. The freight model is based on calculations per tonkm. As such the value of 1.67 € is recalculated with the help of an average train load of 570 ton. \Rightarrow 1.67 € / 570 = 0.002929 € per tonkm.

Internalizing external costs of all modes (road, rail and inland waterways)

External costs are costs that the transport user causes to a third party and for which he does not pay. A distinction can be made between congestion costs, infrastructure costs, environmental costs and accident costs. (Blauwens *et al.* (2008)).

¹⁷ In theory, a difference should be made between Belgian, Dutch and Luxemburg trucks on the one hand and other trucks. Given the fact that the “verkeersbelasting” and “Eurovignette” will disappear for the Belgian, Dutch and Luxemburg trucks, the other trucks have still a cost per kilometre different from zero. However, in the freight model, it was not possible to make this distinction.

“Internalizing external costs of all modes” starts with the assumptions from the “Continuation of current policy” and “Moderate transport policy”. It is now also assumed that the internalization of external costs will also apply to rail transport and inland navigation. This scenario starts from the assumptions of the “Moderate transport policy”.

According to NEA Transport research and training and Universiteit Antwerpen (2007), the following values will be used in the model and applied to all types of infrastructure:

- Road: 0.075 € per tonkm;
- Rail: 0.005 € per tonkm;
- Inland waterways: 0.005 € per tonkm.

In NEA Transport research and training and Universiteit Antwerpen (2007), it is indicated that:

- the values are used for the situation in 2020; in simulations up to 2030, those values are doubled; as such it is assumed that the internalization is introduced in a step-wise approach;
- the values for road are considered quite low, in order to anticipate the effect of a shift to a new equilibrium (decrease of transport volume).

Research about external costs found in CE Delft *et al.* (2008) gives an overview of the estimations of external costs for several modes. It is shown that a variety of values are reported. However it does not make sense to try to use these 2000 values in order to estimate the external costs in 2020. For example, changes in technological evolutions will lead to different values of external costs.

It should be noted that extra inland navigation measures have been introduced under the “Assumptions inland navigation”.

Assumptions inland navigation

In order to simulate cost advantages for inland waterways transport, specific assumptions have been introduced.

- **Continuation of current policy;**
- **Extra measure inland navigation:** yearly cost reduction of 2% of the cost of inland navigation (e.g. as a result of more efficient use of inland waterways).

Port assumptions

In scenarios 9-12 explicit assumptions about the port of Antwerp are taken into account. Scenarios 1-8 and the reference scenarios comprise a growth of the port of Antwerp which is the result of the included economic assumptions: “Following economic assumptions”.

A difference is made between a growth of the port of Antwerp which is following the economic assumptions (scenarios 1-8 and reference scenario), a scenario in which the growth of the port is lower than predicted by the economic assumptions (scenarios 9 and 11) and a scenario in which the growth of the port is higher than predicted by the economic assumptions (scenarios 10 and 12).

The following method is used to make a difference between the types of growth of the port of Antwerp:

- In case of extra growth it is assumed that the incoming flows and outgoing flows in ton for the port of Antwerp are 1.5 times the initially estimated values;
- In case of a lower growth it is assumed that the incoming flows and outgoing flows in ton for the port of Antwerp are half the initial estimated values.

Simulations with extra growth and lower growth can be seen as an approximation of port competition within the freight model.

Assumptions population and household consumption

The evolution of population and household consumption is based on *European Energy and Transport Trends to 2030 – update 2005* (European Commission (2006)). On the basis of this document a growth of the population in Belgium of 0.2% is assumed and a growth of household consumption by 1.7%. The variations of those explaining variables are not assumed in the scenarios.

4.3 Simulation results

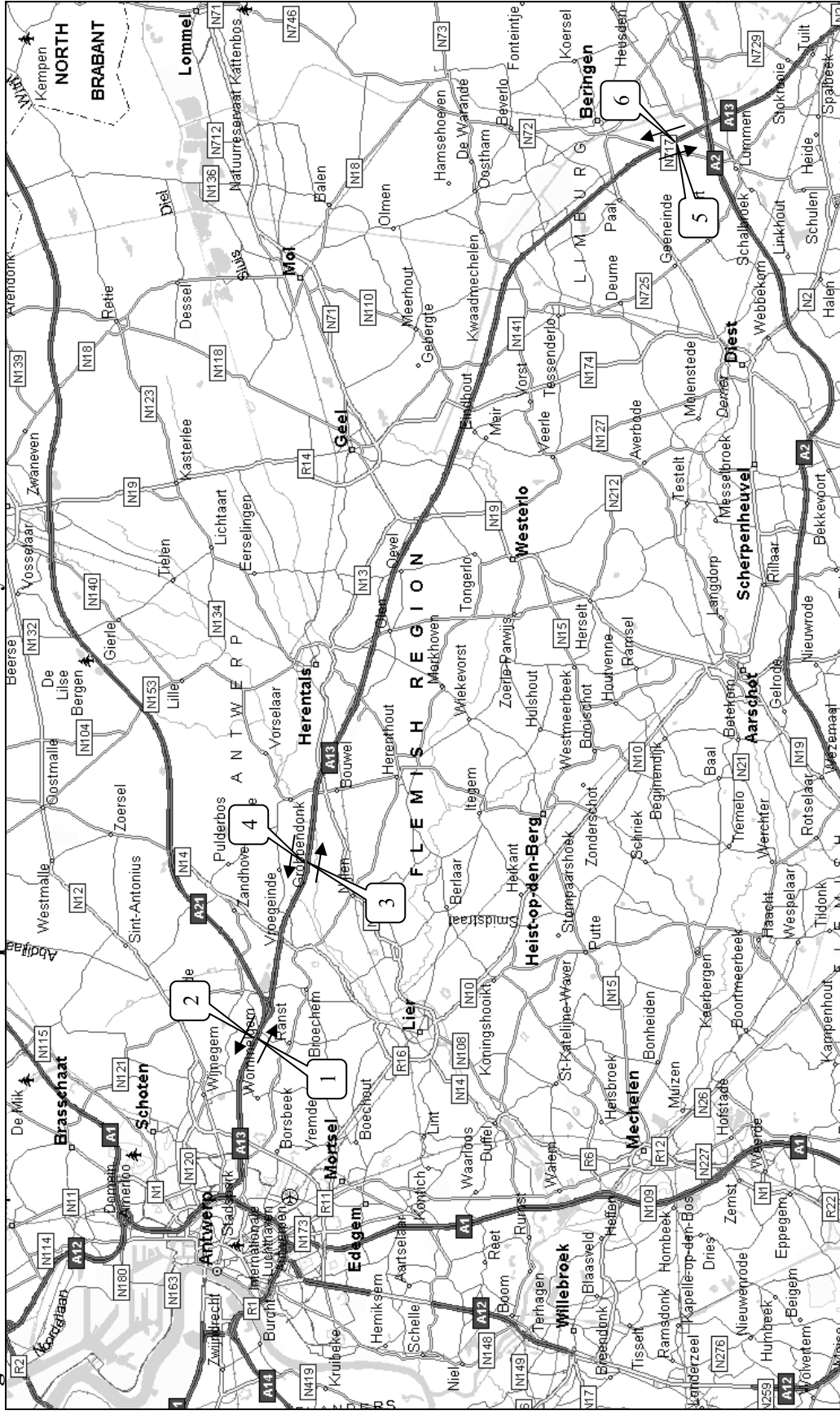
A three-level approach is used to interpret the simulations results. The first level calculates total tonnages and derives growth figures for every scenario. The output refers to specific points on the E313/E34 motorway and hence large variations in the results between the scenarios might be interpreted through shifts among the modes and/or route changes. These effects might come as a result of policies promoting the use of inland navigation or the diversion of traffic due to imposing a tolling system. For a better insight in these issues a second and third level of investigation is performed. The second and third level of investigation is applied when deemed necessary on the basis of the previous findings on the level one. They refer to alternative interpretations of the results according to mode shift and/or route diversion respectively.

In all simulation results the base year is 2004¹⁸, while tonnages in the scenarios refer to 2020. Results (of the first level) refer to specific points on the E313, illustrated in Figure 10. In particular, points 1 and 2 are close to Antwerp and are selected to illustrate the direct effect of the port of Antwerp. Points 3 and 4 are selected in order to give a view on the tonnages after the split between the E313 and E34. Finally, points 5 and 6 are important because they are located in the vicinity of the intersection Lummen (E313 and E314).

It should be noted that the quantitative results are only meant to provide overall trends.

¹⁸The reason for this is the lack of data that the developers of the model have. An update of the data in the model to a more recent year would give similar results to those obtained.

Figure 10: Location of the measurement points on the E313/A13 motorway



Map source: Microsoft MapPoint 2009

4.3.1 Total tonnages and growth investigation

For each selected point on the E313 motorway, the total tonnage passing on that point is calculated. The reference scenario and scenarios 1 to 12 report tonnages in 2020. All 12 scenarios are benchmarked according to:

1. Annual growth figures as compared to the Base 2004 results (see ‘index’, ‘total growth’ and ‘annual growth’ in Tables 10a - 15a)
2. Total tonnages as compared to the reference scenario (see row ‘tonnage’ in Tables 10a - 15a)

The comparison allows for the investigation of the direction, i.e. increase (+) or decrease (-), of total tonnages hence indicating overall trends. The analysis also allows for a comparison of potential policy decisions by observing the behaviour of change in total tonnages from the reference scenario.

Location 1

Results are explained below in detail. In particular Table 10a refers to the actual output of the simulations for location Nr.1. Observations for each scenario follow.

Table 10a: Comparison of scenarios related to location Nr.1

	Base 2004	Ref. sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12
Tonnage (mln tons)	29.82	30.87	30.22	29.58	30.27	19.86	19.38	20.19	19.71	16.12	24.62	37.12	12.89	19.35
Index	100	103.52	101.32	99.19	101.49	66.60	64.97	67.71	66.08	54.05	82.56	124.47	43.22	64.87
Total Growth %	-	3.52	1.33	-0.81	1.49	-33.40	-35.02	-32.29	-33.92	-45.95	-17.44	24.47	-56.78	-35.13
Annual Growth %	-	0.22	0.08	-0.05	0.09	-2.51	-2.66	-2.41	-2.56	-3.77	-1.19	1.38	-5.11	-2.67

Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

The following Table 10b shows the comparison of the output of the simulations to base 2004 and to the reference scenario. An increase in tonnages is marked with “+” and a decrease is marked with “-“. If the increase or decrease is larger than 10% in absolute value, it is marked with the symbol twice. This method is also used in the following Tables 10b - 15b. For some scenarios some special comments or remarks are added. When conclusions are reported about mode shifts and route effects in the comments, this has been investigated further in the text.

Table 10b: Comparison of scenarios to base 2004 and to reference scenarios related to location Nr.1

	Comparison to base 2004*	Comparison to reference scenario*	Comments
Reference scenario	+		
Scenario 1	+	-	Following expectations, no significant effects.
Scenario 2	-	-	Following expectations, no significant effects.
Scenario 3	+	-	Indication of a shift towards inland navigation.
Scenario 4	--	--	Further investigation shows that the tonnage decrease is partially due to route change and not mode shift. This effect is also true in scenarios 5, 6 and 7.
Scenario 5	--	--	The extra decrease as compared to scenario 4 gives an indication of the effect an extra measure of inland navigation has on mode shares.
Scenario 6	--	--	The annual decrease of road transport is smaller in comparison to scenario 4, given the assumption of high economic growth.
Scenario 7	--	--	The extra decrease in comparison with scenario 6 is the effect of the inland navigation measure.
Scenario 8	--	--	Scenario 8 shows a substantial decrease in tonnages, showing the effects of internalizing of external costs.
Scenario 9	--	--	The decrease is the result of the low port factor given the location's proximity to the port of Antwerp.
Scenario 10	++	++	Scenario 10 has exactly opposite results to those of scenario 9, resulting from the high port factor.
Scenario 11	--	--	Scenario 11 shows the same pattern as scenario 8 but it is even more pronounced due to the low port factor.
Scenario 12	--	--	Scenario 12 shows same pattern as scenarios 8 and 11 lying between those two scenarios as a result of the high port factor which moderates the effect of the internalization policy.

*An increase in tonnages is marked with "+" and a decrease is marked with "-", if it is larger than 10% in absolute value, it is marked with the symbol twice.

Location 2

The same exercise is repeated for location Nr. 2 (see map in Figure 10) with traffic in the direction of Antwerp. Comparisons with location Nr.1 are then added focusing on the differences between outgoing (matrix 1) and incoming (matrix 2) flows.

Table 11a: Comparison of scenarios related to location Nr.2

	Base 2004	Ref Sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12
Tonnage (mln tons)	33.97	39.33	38.24	37.51	38.59	25.62	25.06	26.24	25.68	21.65	31.92	46.77	17.33	25.97
Index	100	115.79	112.54	110.41	113.59	75.43	73.77	77.24	75.58	63.73	93.95	137.65	51.02	76.45
Total Growth %	-	15.79	12.54	10.41	13.59	-24.57	-26.23	-22.76	-24.42	-36.27	-6.05	37.65	-48.98	-23.55
Annual Growth %	-	0.92	0.74	0.62	0.80	-1.75	-1.88	-1.60	-1.73	-2.78	-0.39	2.02	-4.12	-1.66

Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Table 11b follows the same pattern as Table 10b. In most scenarios the results are similar in volume and direction. In case of different effects resulting from the scenario based simulations those differences have been included in the comments.

Table 11b: Comparison of scenarios to base 2004 and to reference scenarios related to location Nr.2

	Comparison to base 2004*	Comparison to reference scenario*	Comments
Reference scenario	++		More substantial annual growth.
Scenario 1	++	-	More substantial annual growth.
Scenario 2	++	-	More substantial annual growth.
Scenario 3	++	-	More substantial annual growth.
Scenario 4	--	--	Same as Table 10b, location Nr.1.
Scenario 5	--	--	Same as Table 10b, location Nr.1.
Scenario 6	--	--	Same as Table 10b, location Nr.1.
Scenario 7	--	--	Same as Table 10b, location Nr.1.
Scenario 8	--	--	Same as Table 10b, location Nr.1.
Scenario 9	-	--	Less substantial annual growth.
Scenario 10	++	++	Same as Table 10b, location Nr.1.
Scenario 11	--	--	Same as table 32b, location Nr.1.
Scenario 12	--	--	Same as table 32b, location Nr.1.

*An increase in tonnages is marked with "+" and a decrease is marked with "-", if it is larger than 10% in absolute value, it is marked with the symbol twice.

Location 3

The same exercise is repeated for location Nr. 3 (see map in Figure 10) with traffic away from Antwerp, see Table 12a.

Table 12a: Comparison of scenarios related to location Nr.3

	Base 2004	Ref Sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12
Tonnage (mln tons)	15.60	17.80	17.46	17.08	17.45	13.39	13.04	13.59	13.24	10.71	13.62	21.98	8.13	13.29
Index	100	114.15	111.99	109.55	111.87	85.84	83.61	87.14	84.91	68.67	87.33	140.97	52.10	85.24
Total Growth %	-	14.15	11.99	9.55	11.87	-14.16	-16.39	-12.86	-15.09	-31.33	-12.67	40.97	-47.90	-14.76
Annual Growth %	-	0.83	0.71	0.57	0.70	-0.95	-1.11	-0.86	-1.02	-2.32	-0.84	2.17	-3.99	-0.99

Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Similarly, (as in Table 10b and Table 11b) Table 12b shows the comparison of the output of the simulations to base 2004 and to the reference scenario for the location Nr.3. In order to avoid repetition, the same effects have been quoted by referring to the aforementioned tables.

Table 12b: Comparison of scenarios to base 2004 and to reference scenarios related to location Nr.3

	Comparison to base 2004*	Comparison to reference scenario*	Comments
Reference scenario	++		
Scenario 1	++	-	Substantial annual growth. Following expectations.
Scenario 2	+	-	Following expectations. Slightly lower than in scenario 1 due to additional assumptions on inland navigation. Nevertheless of a minor effect.
Scenario 3	++	-	Substantial annual growth but within expectations. Indication of a possible shift towards inland navigation.
Scenario 4	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 5	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 6	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 7	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 8	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 9	--	--	Significant reduction as a result of the low port factor given that location Nr.3 describes outgoing traffic on the E313.
Scenario 10	++	++	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 11	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.
Scenario 12	--	--	Same as Table 10b and Table 11b, locations nr.1 and 2.

*An increase in tonnages is marked with “+” and a decrease is marked with “-“, if it is larger than 10% in absolute value, it is marked with the symbol twice.

Location 4

The same exercise is repeated for location Nr. 4 (see map in Figure 10) with traffic in the direction of Antwerp.

Table 13a: Comparison of scenarios related to location Nr.4

	Base 2004	Ref Sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12
Tonnage (mln tons)	15.92	19.32	18.88	18.47	18.89	15.35	14.95	15.68	15.28	12.79	14.59	24.05	9.47	16.12
Index	100	121.34	118.56	115.98	118.61	96.40	93.90	98.46	95.96	80.33	91.67	151.03	59.48	101.21
Total Growth %		21.34	18.56	15.98	18.61	-3.60	-6.10	-1.54	-4.04	-19.67	-8.33	51.03	-40.52	1.21
Annual Growth %		1.22	1.07	0.93	1.07	-0.23	-0.39	-0.10	-0.26	-1.36	-0.54	2.61	-3.19	0.08

Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Table 13b shows the comparison of the output of the simulations to base 2004 and to the reference scenario for the location Nr.4. Comments highlight comparisons with location Nr 3 and refer to the similarities with all previously analyzed locations 1, 2 and 3.

Table 13b: Comparison of scenarios to base 2004 and to reference scenarios related to location Nr.4

	Comparison to base 2004*	Comparison to reference scenario*	Comments
Reference scenario	++		
Scenario 1	++	-	Same as Table 12b, location Nr.3.
Scenario 2	++	-	More substantial annual growth than location Nr.3.
Scenario 3	++	-	Same as Table 12b, location Nr.3.
Scenario 4	-	--	Less substantial growth than Table 12b, location Nr.3.
Scenario 5	-	--	Annual growth is slightly higher than for location Nr.3, but still negative.
Scenario 6	-	--	Decrease in total tonnages despite the high economic growth situation and international trade increase, Annual growth is negative, but close to zero.
Scenario 7	-	--	Annual growth is negative, but higher than for location Nr.3.
Scenario 8	--	--	Same as Table 10b, Table 11b and Table 12b, locations Nr.1, 2 and 3.
Scenario 9	-	--	Less pronounced negative growth, similar decrease in tonnages as location Nr.3
Scenario 10	++	++	Same as Table 10b, Table 11b and Table 12b, locations nr.1, 2 and 3.
Scenario 11	--	--	Same as Table 10b, Table 11b and Table 12b, locations nr.1, 2 and 3.
Scenario 12	+	--	From negative to positive annual growth although of minor level. Similar decrease in tonnages as location Nr.3.

*An increase in tonnages is marked with "+" and a decrease is marked with "-", if it is larger than 10% in absolute value, it is marked with the symbol twice.

Location 5

The same exercise is repeated for location Nr. 5 (see map in Figure 10) with traffic away from Antwerp, see Table 14a.

Table 14a: Comparison of scenarios related to location Nr.5

	Base 2004	Ref Sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12
Tonnage (mln tons)	17.98	20.50	20.09	19.56	19.99	17.48	17.02	17.83	17.36	14.47	17.04	23.96	12.53	16.41
Index	100	113.97	111.72	108.76	111.13	97.21	94.66	99.12	96.55	80.45	94.74	133.21	69.68	91.22
Total Growth %		13.97	11.72	8.76	11.13	-2.79	-5.34	-0.88	-3.45	-19.55	-5.26	33.21	-30.32	-8.78
Annual Growth %		0.82	0.70	0.53	0.66	-0.18	-0.34	-0.06	-0.22	-1.35	-0.34	1.81	-2.23	-0.57

Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Table 14b shows the comparison of the output of the simulations to base 2004 and to the reference scenario for the location Nr.5.

Table 14b: Comparison of scenarios to base 2004 and to reference scenarios related to location Nr.5

	Comparison to base 2004*	Comparison to reference scenario*	Comments
reference scenario	++		
Scenario 1	++	-	Substantial annual growth. Following expectations.
Scenario 2	+	-	Following expectations. Slightly lower than in scenario 1 due to additional assumptions on inland navigation. Nevertheless of a minor effect.
Scenario 3	++	-	Substantial annual growth but within expectations. Indication of a shift towards inland navigation.
Scenario 4	-	--	Less pronounced annual growth reduction.
Scenario 5	-	--	Less pronounced annual growth reduction.
Scenario 6	-	--	Less pronounced annual growth reduction.
Scenario 7	-	--	Less pronounced annual growth reduction.
Scenario 8	--	--	Same as Table 10b, Table 11b, Table 12b and Table 13b, locations Nr.1, 2, 3 and 4.
Scenario 9	-	--	Less pronounced annual growth reduction.
Scenario 10	++	++	Same as Table 10b, Table 11b, Table 12b and Table 13b, locations Nr.1, 2, 3 and 4.
Scenario 11	--	--	Same as Table 10b, Table 11b, Table 12b and Table 13b, locations Nr.1, 2, 3 and 4.
Scenario 12	-	--	Less pronounced annual growth reduction.

*An increase in tonnages is marked with "+" and a decrease is marked with "-", if it is larger than 10% in absolute value, it is marked with the symbol twice.

Location 6

The same exercise is repeated for location Nr. 6 (see map in Figure 10) with traffic in the direction of Antwerp. Comparisons with location Nr.5 are then added focusing on the differences between outgoing (location Nr.5) and incoming (location Nr.6) flows in this location.

Table 15a: Comparison of scenarios related to location Nr.6

	Base 2004	Ref Sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12
Tonnage (mln tons)	16.50	19.65	19.21	18.78	19.21	16.92	16.52	17.30	16.89	14.18	16.03	23.28	11.92	16.45
Index	100	119.12	116.48	113.84	116.45	102.58	100.13	104.84	102.39	85.98	97.14	141.10	73.26	99.70
Total Growth %	-	19.12	16.48	13.84	16.45	2.58	0.13	4.84	2.39	-14.02	-2.86	41.10	-27.74	-0.30
Annual Growth %	-	1.10	0.96	0.81	0.96	0.16	0.01	0.30	0.15	-0.94	-0.18	2.18	-2.01	-0.02

Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Table 15b shows the comparison of the output of the simulations to base 2004 and to the reference scenario for the location Nr.6.

Table 15b: Comparison of scenarios to base 2004 and to reference scenarios related to location Nr.6

	Comparison to base 2004*	Comparison to reference scenario*	Comments
Reference scenario	++		
Scenario 1	++	-	Same as Table 14b, location Nr.5.
Scenario 2	++	-	Same as Table 14b, location Nr.5. Slightly higher annual growth.
Scenario 3	++	-	Same as Table 14b, location Nr.5. Slightly higher annual growth.
Scenario 4	+	--	Annual growth increase compared to base 2004, contrary to decrease for location Nr.5. This is also true in scenarios 5, 6 and 7. In location Nr.6 (in the direction of Antwerp) the assumptions in scenarios 4 to 7 influence the goods flow less than in location Nr.5 (in the direction away from Antwerp).
Scenario 5	+	--	From negative to positive annual growth. Similar decrease in tonnages as location Nr.5.
Scenario 6	+	--	From negative to positive annual growth. Similar decrease in tonnages as location Nr.5.
Scenario 7	+	--	From negative to positive annual growth. Similar decrease in tonnages as location Nr.5.
Scenario 8	--	--	Same as Table 10b, Table 11b, Table 12b, Table 13b and Table 14b, locations Nr.1, 2, 3, 4 and 5.
Scenario 9	-	--	Same as Table 14b, location Nr.5.
Scenario 10	++	++	Same as Table 14b, location Nr.5.
Scenario 11	--	--	Same as Table 14b, location Nr.5.
Scenario 12	-	--	Same as Table 14b, location Nr.5. The annual growth is close to zero.

*An increase in tonnages is marked with "+" and a decrease is marked with "-", if it is larger than 10% in absolute value, it is marked with the symbol twice.

4.3.2 Network analysis: route change

Route change investigation is done using difference plot, an illustration tool of the Cube software.

The purpose of this application is to use the difference plot for illustrating the different scenarios in both colour and thickness. Hence, the scenarios for which this investigation has been deemed necessary are benchmarked with the reference scenario, showing whether an increase or decrease in tonnages has taken place.

In particular what is shown by the different colours could be summarized as follows:

- Red lines show an increase of more than hundred tons;
- Green lines show a decrease of more than hundred tons;

- Grey lines show minor differences, indicating that the scenarios have an insignificant effect on the tonnages transported on the specific network link;

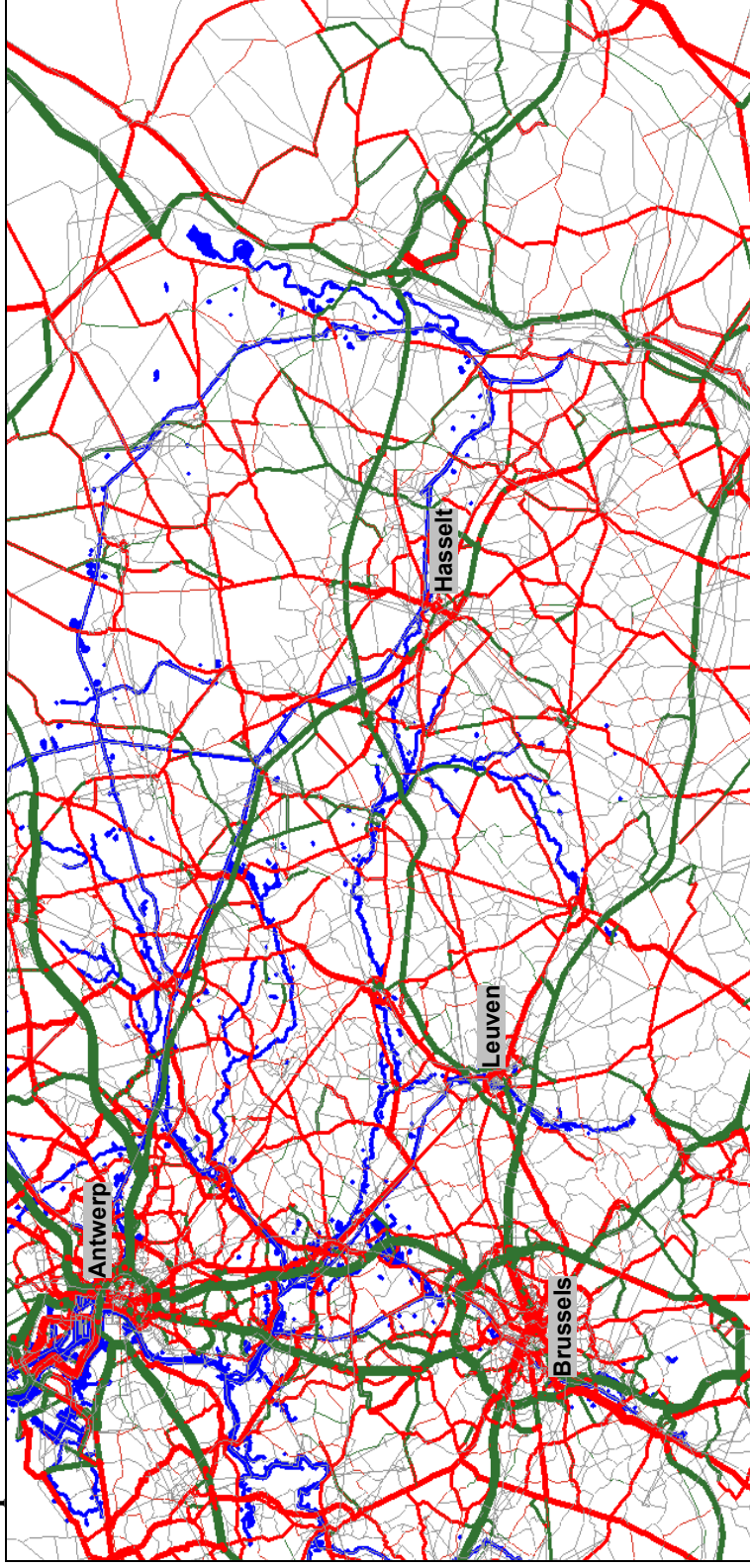
On the other hand the thickness of the lines represents the volume of tonnages for each link. Three levels of thickness have been defined (see size column in Table 16). Table 16 also shows which colours are being used according to which criteria.

Table 16: Difference plot criteria (road network)

Tonnage change	Size	Colour
>10.000	1	Red
<-10.000	1	Green
>=-10.000 & <=10.000	1	Grey
>=100.000	3	Red
<=-100.000	3	Green
>=1.000.000	5	Red
<=-1.000.000	5	Green
>=10.000.000	8	Red
<=-10.000.000	8	Green

According to the first level of investigation the most interesting scenarios for practical implementation are scenarios 4, 5, 6 and 7 that refer to the moderate policy assumption and its variations and 8, 11 and 12 which correspond to the internalization policy assumption and its variations. Each scenario is further explained below.

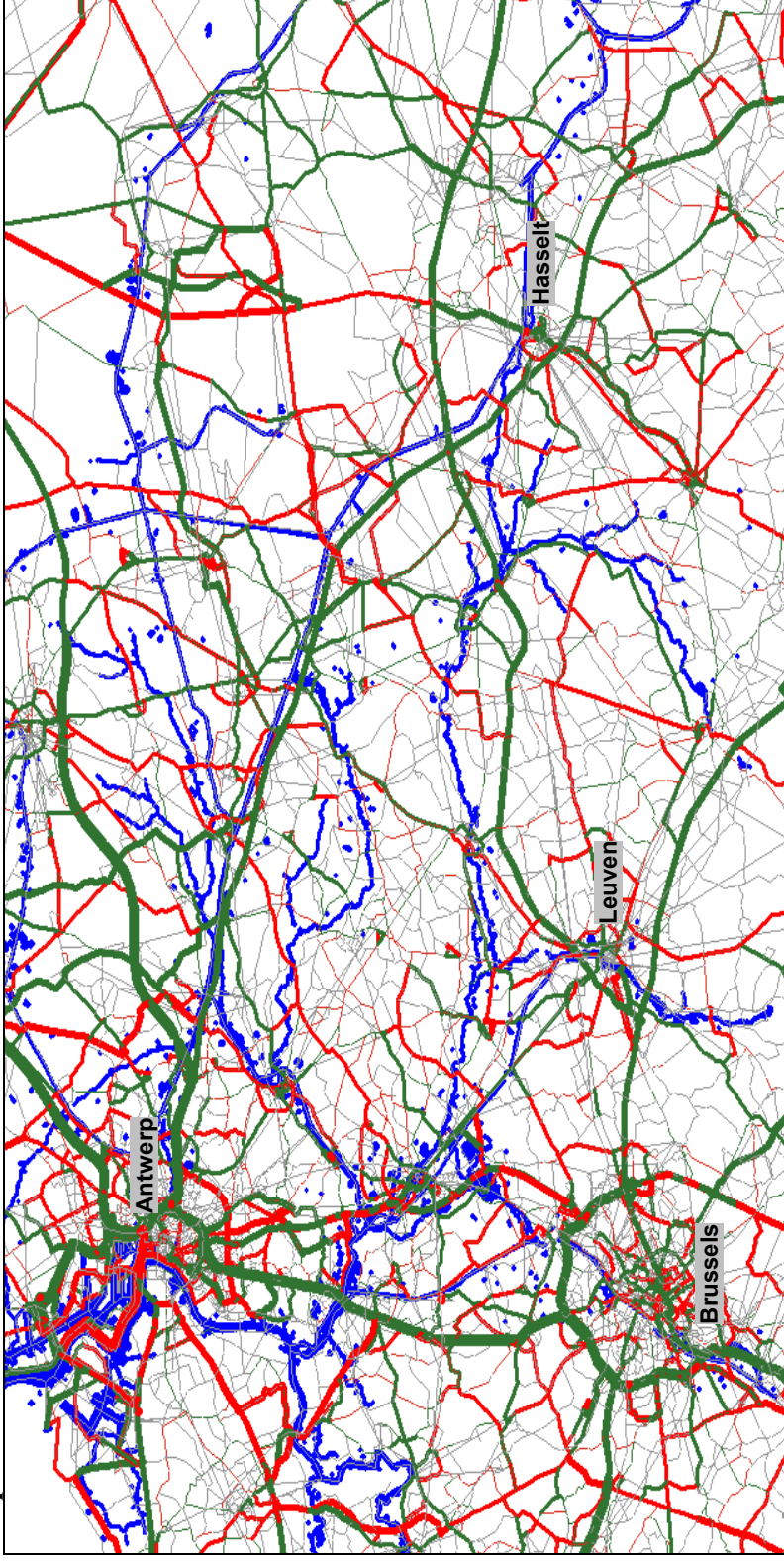
Graph 1: Scenario 4 versus reference scenario



Source: Aronietis *et al.* (2009) based on Freight model Flanders

In scenario 4, total tonnages for the selected points on the E313 when compared to the reference scenario decrease. This is illustrated by the green color on the network. Clearly, route changes in terms of an increase in tonnages are observed on the non-highway network as shown by the red lines.

Graph 2: Scenario 4bis versus reference scenario

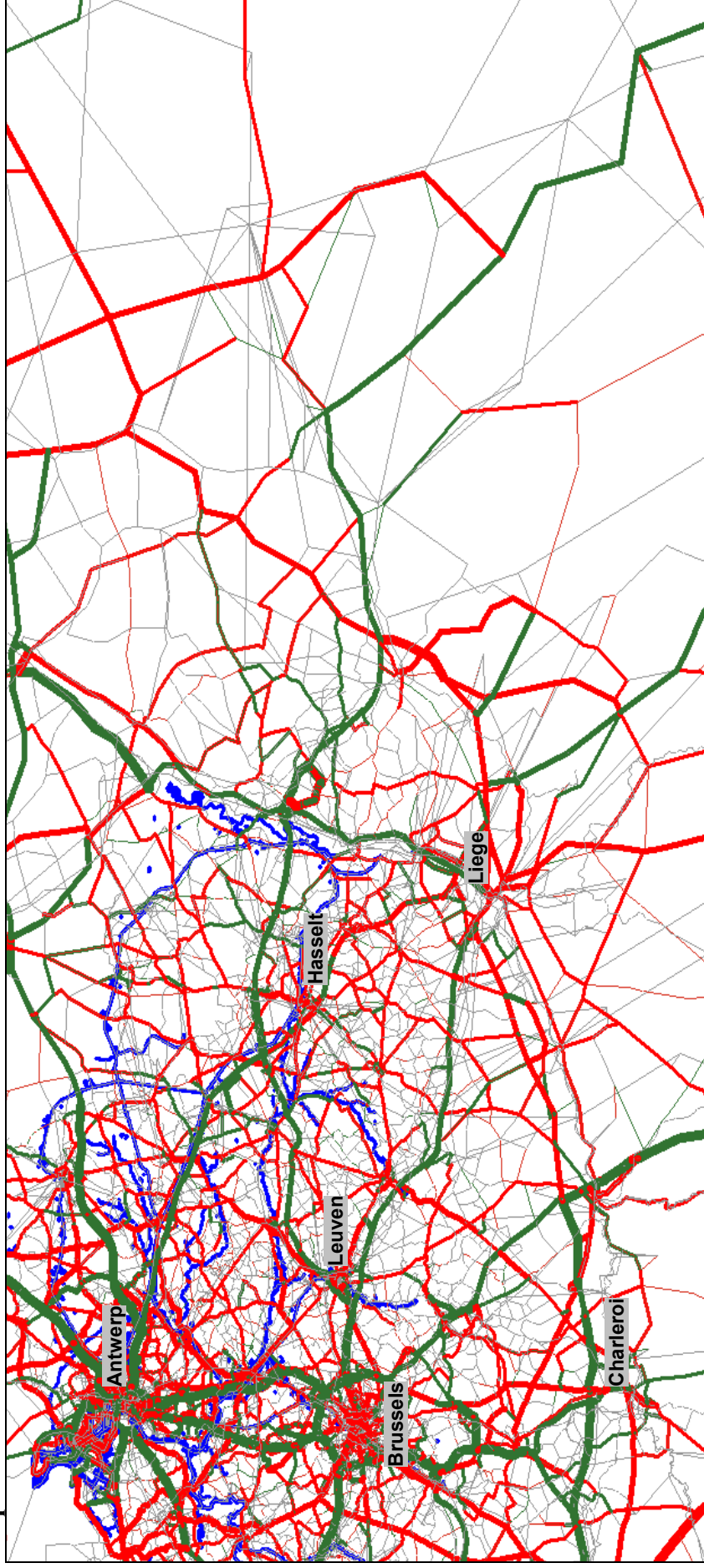


Source: Aronietis *et al.* (2009) based on Freight model Flanders

Given the results of Scenario 4 an alternative Scenario 4bis is run. It differs from scenario 4 by the addition of a kilometer costs variable (km costs other= 0.15) to the rest of the network together with the km cost on the highways (km costs highways= 0.15).

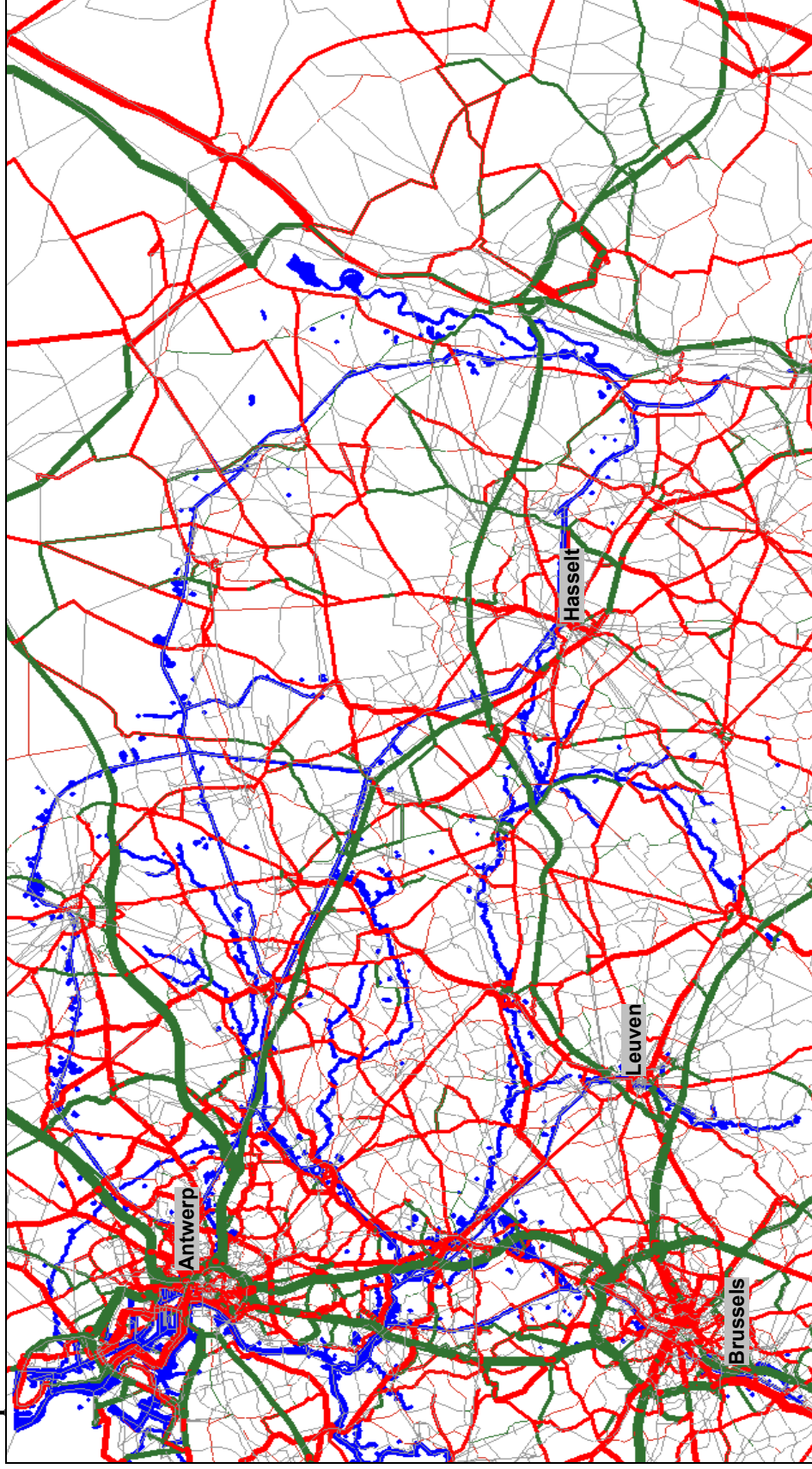
The results of this simulation seem to differ substantially from scenario 4. On the overall the decrease in tonnages (green lines) has become more widespread in the network. Given only minor differences between the scenarios 5, 6 and 7 (shown in graphs 3, 4 and 5 respectively) with scenario 4, a similar network effect is expected. For this aggregate level of investigation the main conclusion drawn is that route diversion occurs when a moderate policy in terms of kilometer costs charging on the highways is being enforced.

Graph 3: Scenario 5 versus reference scenario



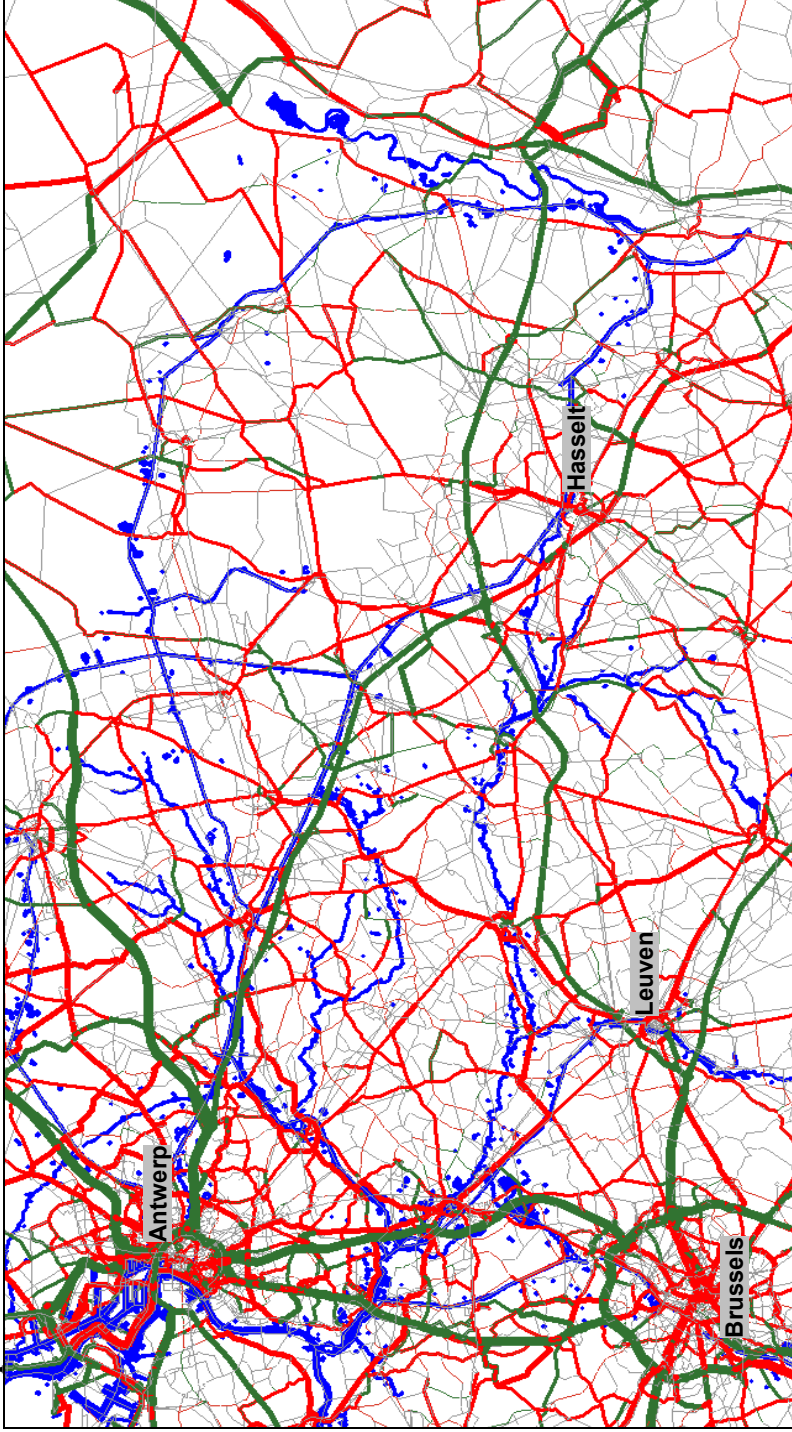
Source: Aronietis *et al.* (2009) based on Freight model Flanders

Graph 4: Scenario 6 versus reference scenario



Source: Aronietis *et al.* (2009) based on Freight model Flanders

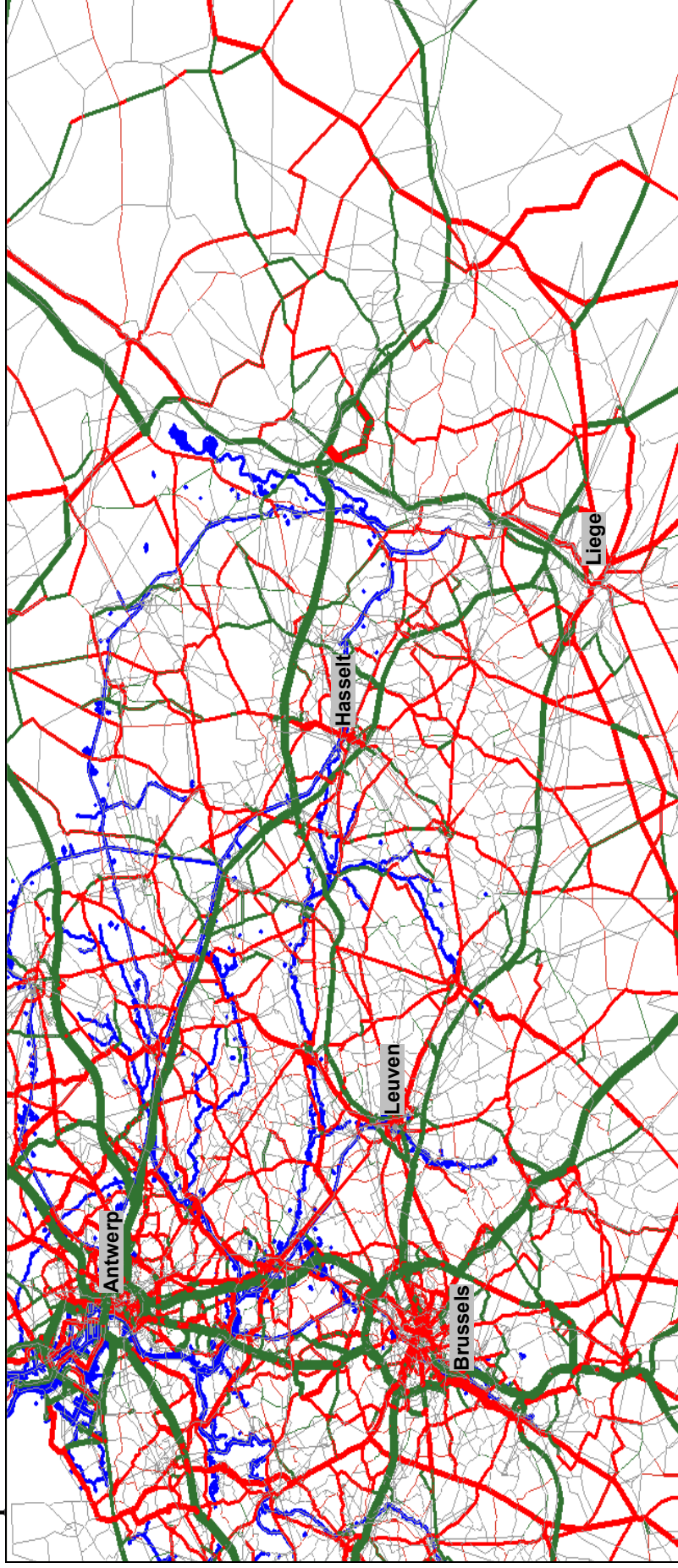
Graph 5: Scenario 7 versus reference scenario



Source: Aronietis *et al.* (2009) based on Freight model Flanders

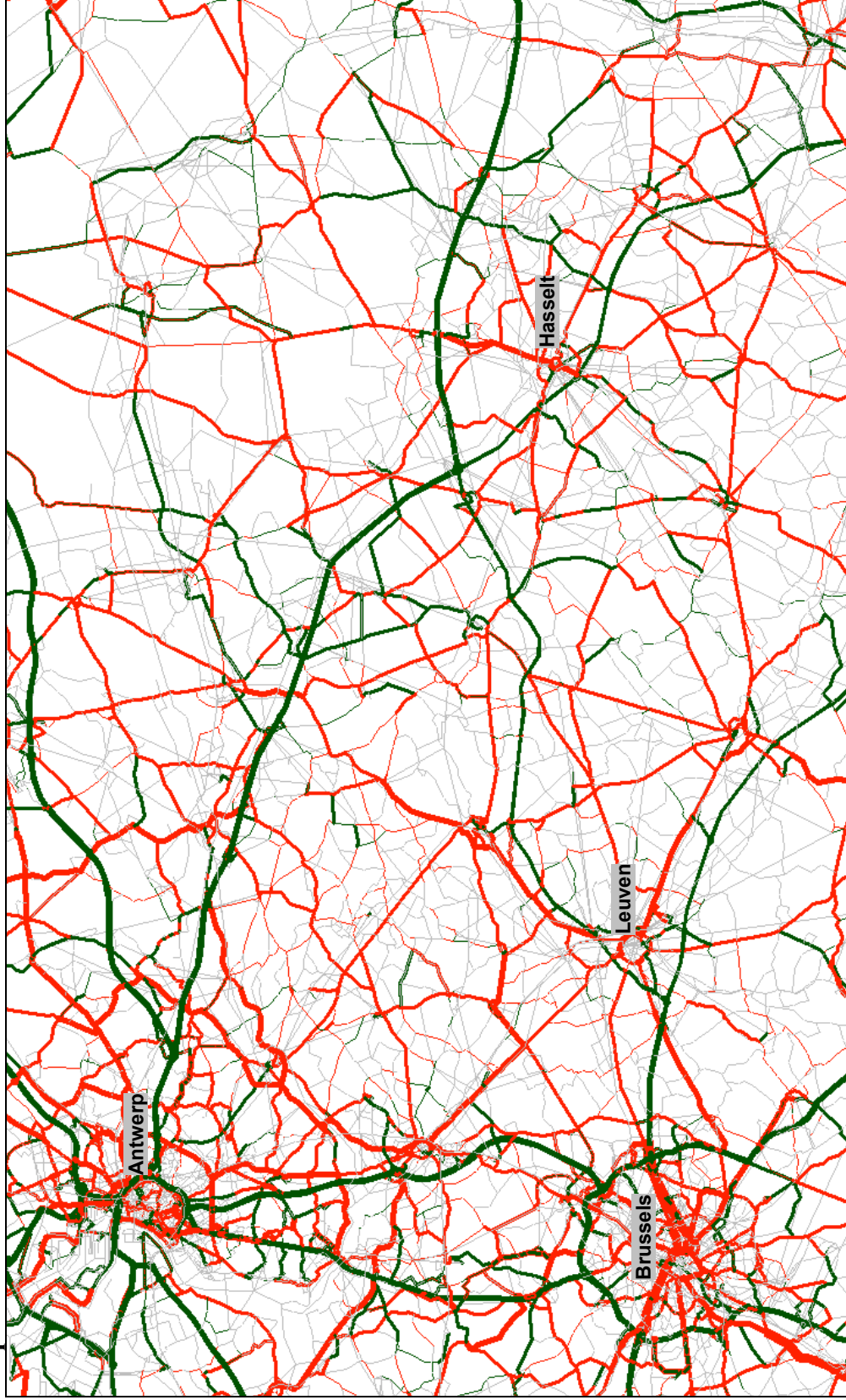
Scenarios 8, 11, 12 of the internalization policy (found in Graphs 6, 7 and 8 respectively) show once more the same network pattern but with the effects being more pronounced than the scenarios of moderate policy. Given the focus of this study on the E313 motorway, simulations of a variety of policies show the overall sensitivity of its transported traffic volumes, in terms of tonnages, to charging policies. Nevertheless, a more in depth analysis would be necessary when evaluating the appropriateness of such policies.

Graph 6: Scenario 8 versus reference scenario



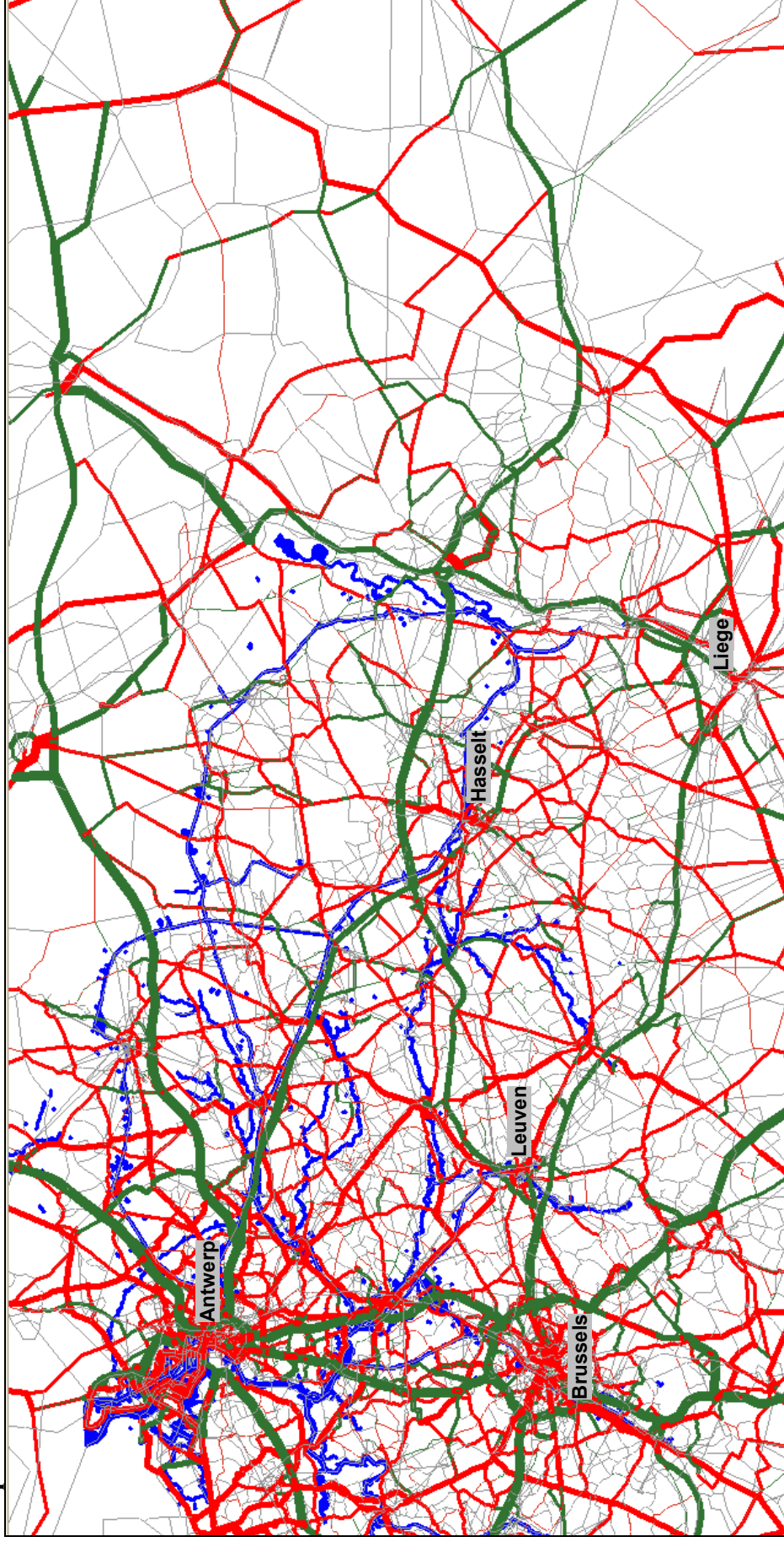
Source: Aronietis *et al.* (2009) based on Freight model Flanders

Graph 7: Scenario 11 versus reference scenario



Source: Aronietis *et al.* (2009) based on Freight model Flanders

Graph 8: Scenario 12 versus reference scenario



Source: Aronietis *et al.* (2009) based on Freight model Flanders

4.3.3 Mode Shift

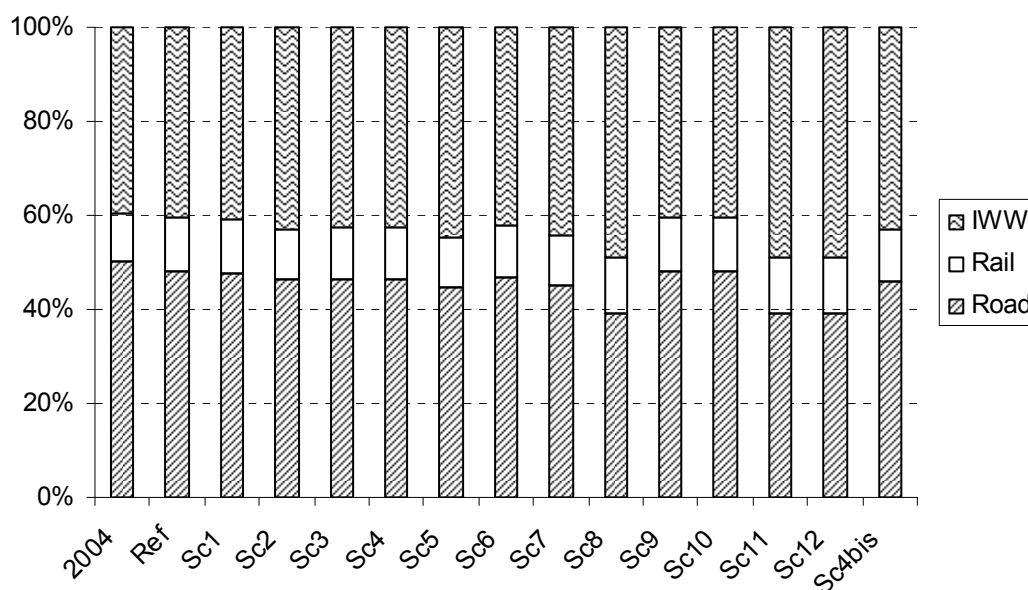
Four regions have been selected to analyze the mode shift effects of the scenarios: the port of Antwerp, the county of Antwerp (excl. Port of Antwerp), the region of Turnhout and the region of Hasselt. The E313 passes through all the aforementioned regions.

For each region, the total incoming and outgoing flows in tonnes have been calculated for road, rail and inland waterways (IWW). This enables the calculation of the modal split for the base year 2004, the reference scenario and the specific scenarios (1-12 and 4bis).

Incoming flows

In the port of Antwerp, it is known that the use of inland navigation is very important, which has been confirmed in Figure 11. The scenarios 8, 11 and 12 show the highest effect on the choice of road transport (decrease in comparison with the base year 2004 and the reference scenario). In those three scenarios, the policy of internalizing external costs of all modes was assumed. According to the simulation results of the freight model, it turns out that the shift of road transport is mainly towards inland navigation.

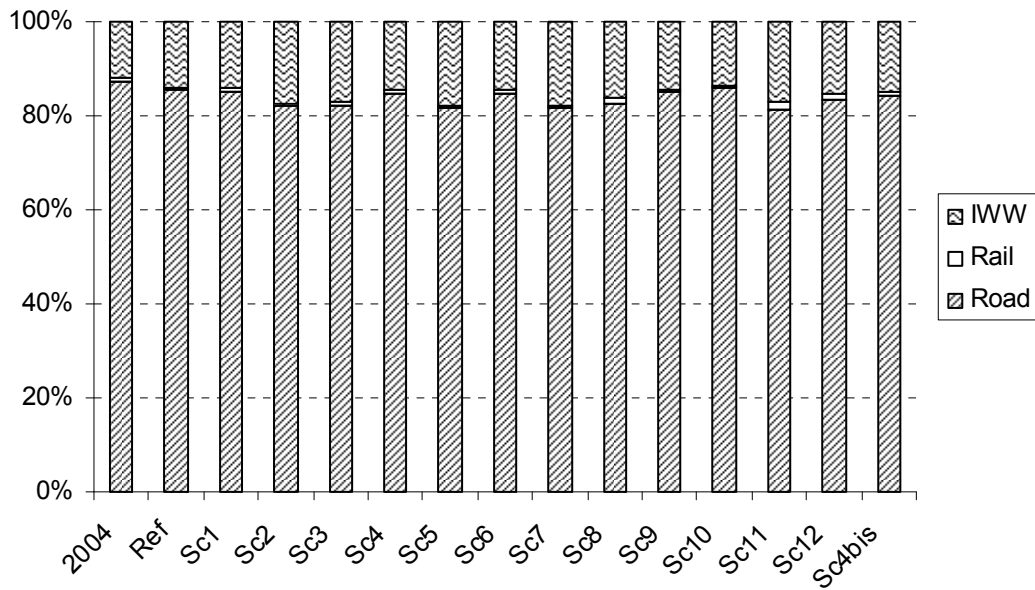
Figure 11: Port of Antwerp



Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

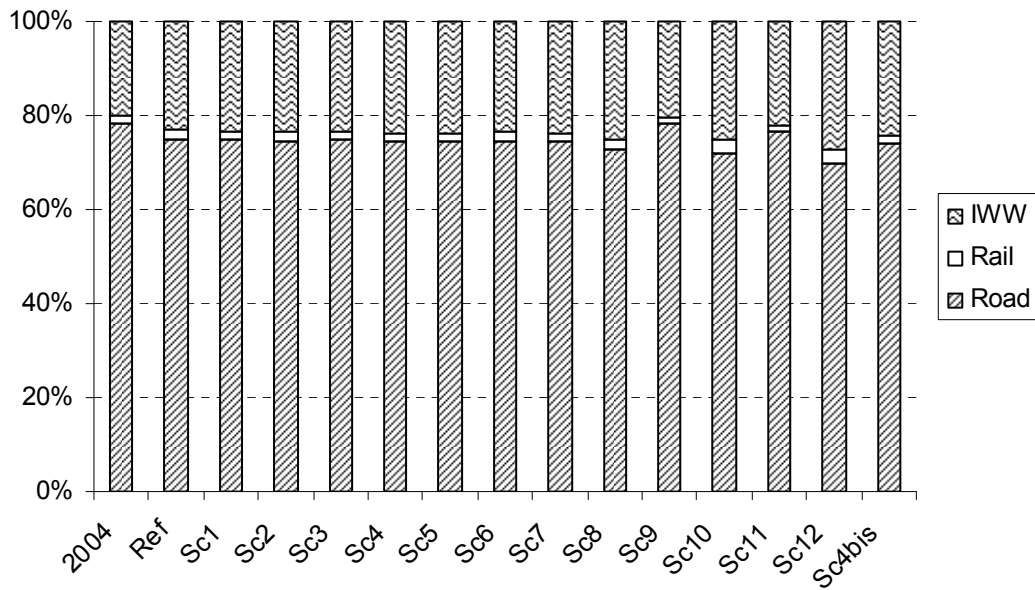
In the other regions, the decreasing effects on road transport of internalizing all external costs can also be seen. However, in absolute values, these effects are smaller in comparison with the port of Antwerp. According to the freight model, it turns out that the port-related traffic is sensitive to the policy assumptions made in the scenarios.

Figure 12: Region of Antwerp (NUTS-3) excl. Port of Antwerp



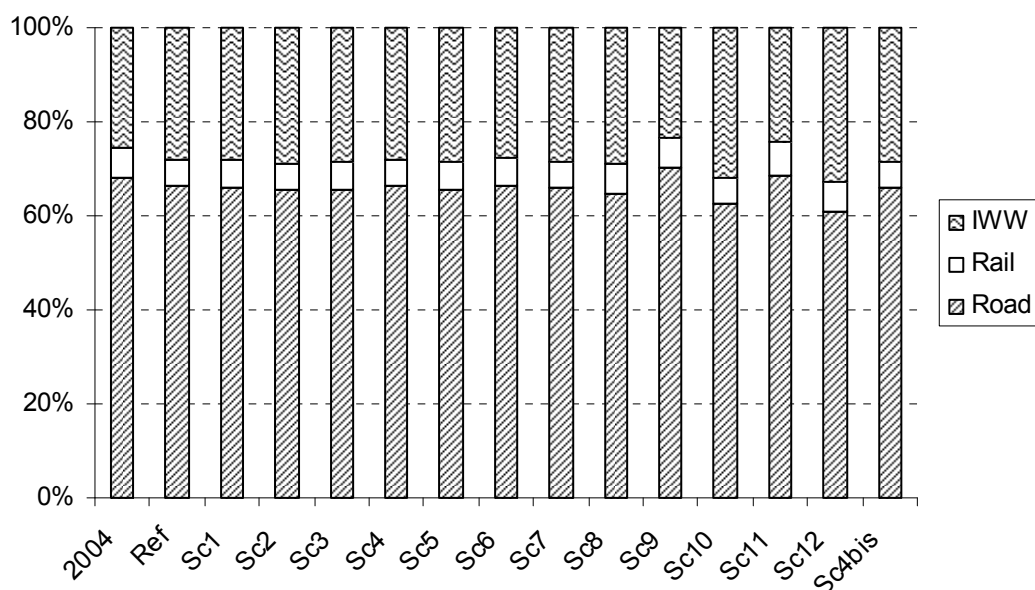
Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Figure 13: Region of Turnhout (NUTS-3)



Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Figure 14: Region of Hasselt (NUTS-3)



Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

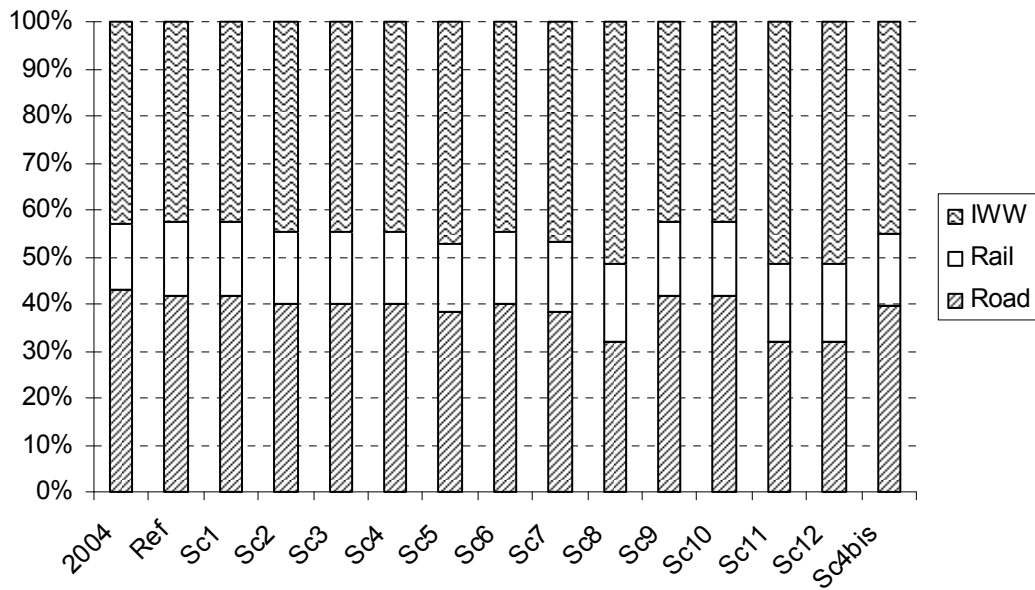
In all regions the scenarios introducing the extra measure for inland navigation (scenarios 2, 3, 5 and 7) do not seem to significantly influence the mode choice (expressed in percentages). Moreover, the same effect is observed in the scenarios for which a moderate policy is assumed (scenarios 4, 5, 6 and 7). The latter, combined with the network investigation (see chapter 5.3.2) demonstrate that the decrease in tonnages in the investigated points on the E313 is a result of route changes rather than mode shifts.

Outgoing flows

The underlying figures of outgoing flows from the port of Antwerp show a higher modal part of inland navigation in the port of Antwerp, in comparison with the incoming flows and as shown also in Figure 11.

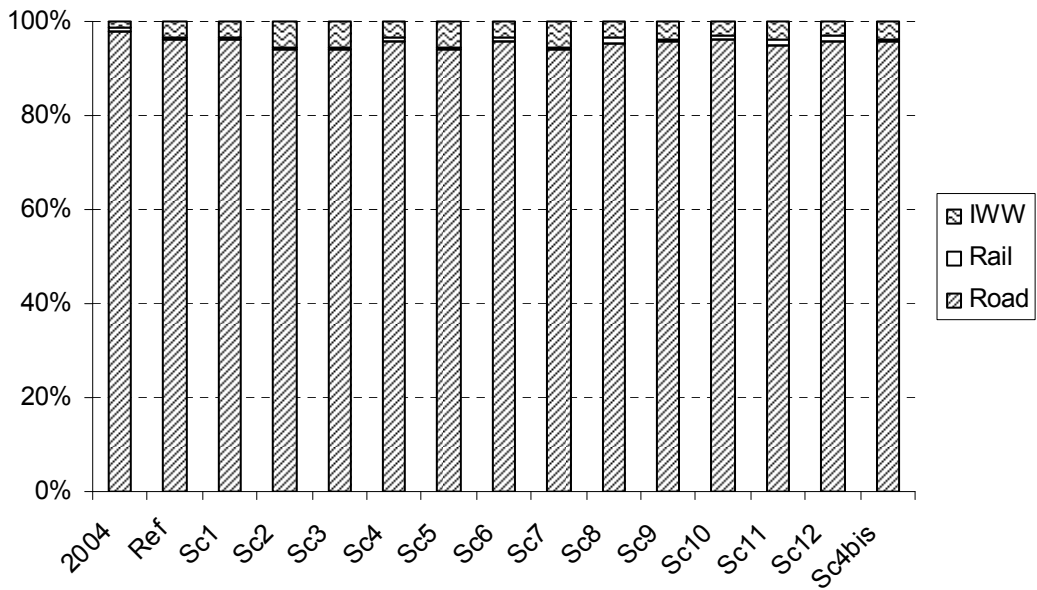
The effects of the several scenarios are similar for the outgoing flows compared to the effects for the incoming flows.

Figure 15: Port of Antwerp



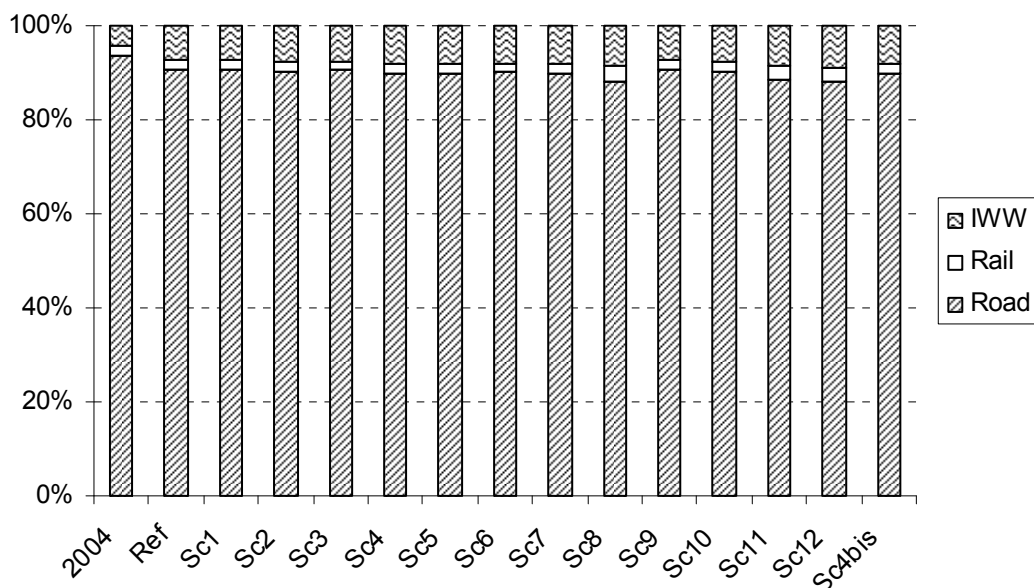
Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Figure 16: Region of Antwerp (NUTS-3) excl. Port of Antwerp



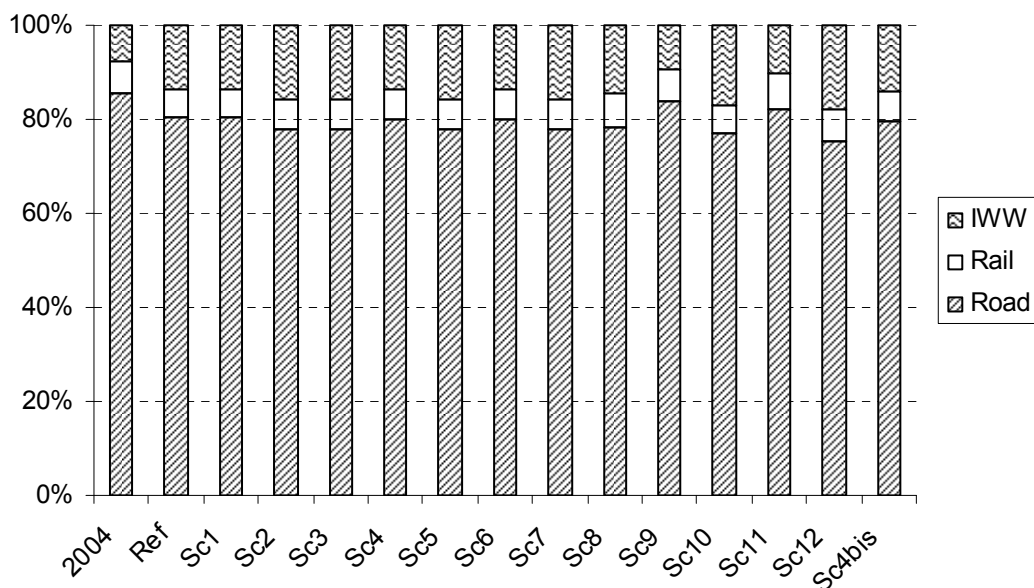
Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Figure 17: Region of Turnhout (NUTS-3)



Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Figure 18: Region of Hasselt (NUTS-3)



Source: Aronietis *et al.* (2009) based on simulations with the Freight model Flanders

Region Antwerp, Mechelen, Turnhout and Sint-Niklaas

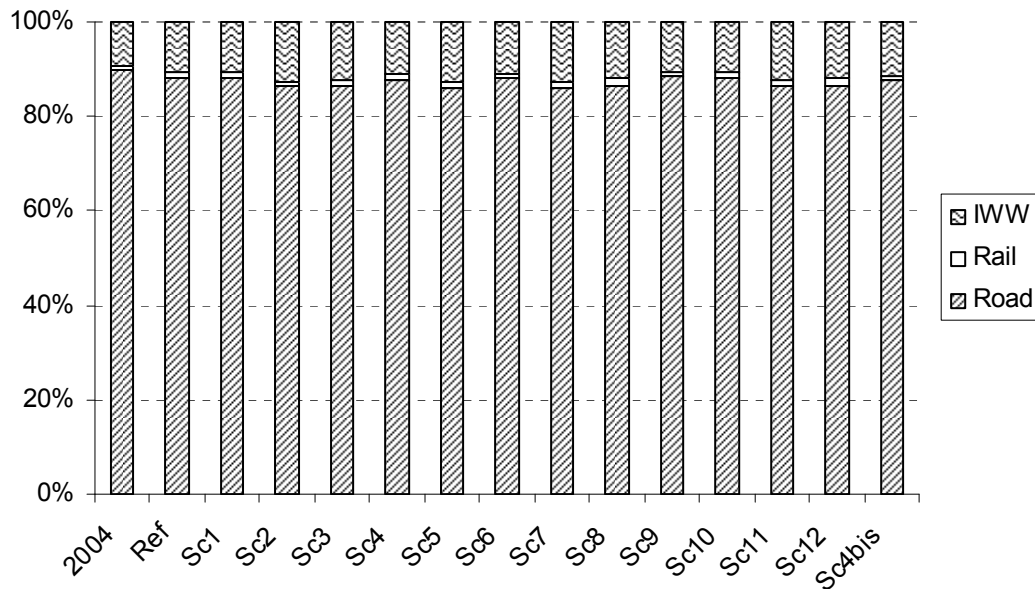
A separate analysis has been performed for the region Antwerp, Mechelen, Turnhout and Sint-Niklaas as one study area. In the following Table 17 and Figure 19 an overview is given of the mode split, taking into account the incoming and the outgoing flows.

Table 17: Mode split (region Antwerp, Mechelen, Turnhout and Sint-Niklaas)

	Road	Rail	IWW
2004	89,63	0,98	9,38
Ref	88,31	0,99	10,70
Sc1	88,25	0,99	10,76
Sc2	86,53	0,96	12,51
Sc3	86,59	0,96	12,45
Sc4	87,88	1,01	11,11
Sc5	86,10	0,98	12,92
Sc6	87,94	1,01	11,05
Sc7	86,16	0,97	12,87
Sc8	86,35	1,64	12,01
Sc9	88,45	0,82	10,73
Sc10	88,20	1,13	10,67
Sc11	86,25	1,52	12,23
Sc12	86,43	1,74	11,84
Sc4bis	87,51	1,07	11,42

Source: Aronietis *et al.* (2009) based on Freight model Flanders

Figure 19: Mode split (region Antwerp, Mechelen, Turnhout and Sint-Niklaas)



Source: Aronietis *et al.* (2009) based on Freight model Flanders

For the region of Antwerp, Mechelen, Turnhout and Sint-Niklaas (regions 11, 12, 13 and 46 taken together) the introduction of the extra measure for inland navigation (scenario 3) results in a 1.8% mode share increase for inland navigation.

Region Antwerp, Mechelen, Turnhout, Sint-Niklaas and port of Antwerp

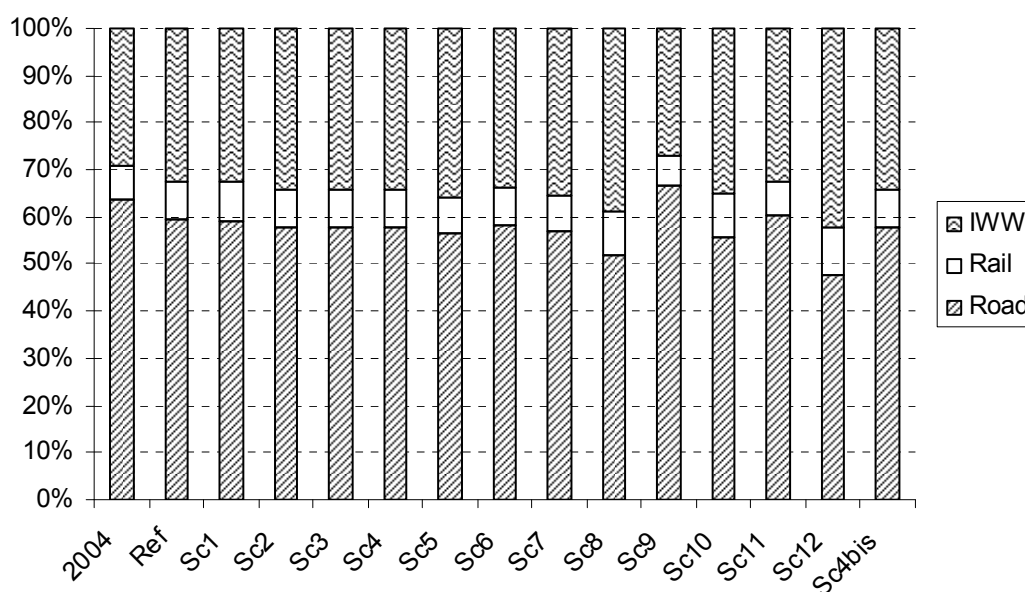
A separate analysis has been performed also for the region Antwerp, Mechelen, Turnhout, Sint-Niklaas and the port of Antwerp as another study area. In Table 18 and Figure 20 an overview is given of the mode split, taking into account the incoming and the outgoing flows.

Table 18: Mode split (region Antwerp, Mechelen, Turnhout, Sint-Niklaas and port of Antwerp)

	Road	Rail	IWW
2004	63,71	7,35	28,94
Ref	59,35	8,30	32,35
Sc1	59,09	8,31	32,59
Sc2	57,74	8,00	34,26
Sc3	58,02	7,98	34,01
Sc4	57,96	7,98	34,06
Sc5	56,59	7,65	35,76
Sc6	58,23	7,98	33,79
Sc7	56,86	7,65	35,48
Sc8	51,87	9,18	38,96
Sc9	66,55	6,41	27,04
Sc10	55,78	9,24	34,98
Sc11	60,29	7,26	32,46
Sc12	47,69	10,13	42,18
Sc4bis	57,74	7,96	34,29

Source: Aronietis *et al.* (2009) based on Freight model Flanders

Figure 20: Mode split (region Antwerp, Mechelen, Turnhout, Sint-Niklaas and port of Antwerp)



Source: Aronietis *et al.* (2009) based on Freight model Flanders

4.4 Interpretations of the scenarios

Each scenario tested could be an alternative innovation to consider for implementation. The results from scenario runs in this chapter provide an overview of the possible impacts that could arise from the implementation of those scenarios for tackling the congestion problem on the port hinterland links.

The interpretations from the scenario runs are the following, listed per scenario:

- Scenario 1 differs from the reference scenario with low economic growth assumptions and low growth assumptions for export and import. The result of these assumptions on the goods flows on the motorway E313 is as expected – the volumes of the goods flows and also the annual growth has decreased in all the locations on the motorway. The model successfully captures the decrease in economic growth and international trade and links it to the lower growth of goods flows on the motorway E313.
- Scenario 2 differs from scenario 1 by an extra assumption on inland navigation – a yearly cost reduction of 2% of the cost of inland navigation, e.g. as a result of more efficient use of inland waterways. The inland navigation assumption in scenario 2 reinforces the effect of low economic and trade assumptions and reduces the tonnages even further in all the reviewed locations on the motorway. The effect tends to be bigger on goods flows in the direction away from Antwerp.
- Scenario 3 starts with the reference scenario and adds only the assumption on the yearly cost reduction of inland navigation (as in scenario 2). In this case the model demonstrates the mode shift effects of the inland navigation measures. The cost reduction allows reaching the objective of mode shift towards inland navigation. It must be mentioned that the shift is moderate.
- Scenario 4 starts with the reference scenario and introduces road pricing set to 0.15 € per kilometer in the Benelux, which is applied on the highways. This does not apply to local roads. The effects of this situation are as expected: the goods flows on the motorway E313 reduce substantially. However this is associated with adverse effects to the local roads for which the charging is not in force. Further investigation of the situation (see Graph 1) showed that a certain part of the traffic chooses alternative routes instead of shifting modes. This phenomenon tends to be more pronounced on the points of the motorway E313 closer to Antwerp.
- Scenario 5 starts with road pricing assumptions like in scenario 4 and adds the assumptions for inland navigation from scenario 3 thus combining those two scenarios. The combination of the measures gives the expected effect and the goods flows decrease. This decrease is partially due to mode shift, but also due to changes in route choice for road transport.
- Scenario 6 introduces road pricing in a high growth economic situation with high export and import growth. If compared to scenario 4 (only road pricing, see above), the effects of road pricing on goods flows on motorway E313 are less pronounced due to extra assumptions in the scenario. However it can be speculated that the reduction in traffic flows on the E313 that scenario 6 demonstrates brings with it similar adverse effects to other parts of the transport network as in scenario 4.
- Scenario 7 adds extra assumptions on inland navigation (see Table 8 for details) to the existing scenario 6. If compared to scenario 6, a slight decrease in tonnages can be seen in all matrixes as a result of the extra inland navigation assumption.
- Scenario 8 starts with a reference scenario and brings in internalization of external costs for all modes – all parts of transport networks are charged. This policy gives a substantial effect if compared to measures tested in other scenarios.
- Scenarios 9 and 10 test the effect of the growth of the Port of Antwerp on goods flows on the motorway E313. There is a slight decrease in goods flows in the low port growth situation and an opposite effect in the high growth situation.
- Scenario 11 adds to scenario 8 a low port growth factor which, as expected, has a reinforcing effect on the internalization policy of external costs.

- Scenario 12, however adds a high port growth factor to scenario 8. This has a weakening effect on the internalization policy of external costs.

Table 19 presents the comparison of indexes for the scenarios that were modelled for the different selected locations.

Table 19: Comparison of indexes for the selected locations

	Ref Sc.	Sc.1	Sc.2	Sc.3	Sc.4	Sc.5	Sc.6	Sc.7	Sc.8	Sc.9	Sc.10	Sc.11	Sc.12	Sc. 4bis
Loc. 1	104	101	99	101	67	65	68	66	54	83	124	43	65	79
Loc. 2	116	113	110	114	75	74	77	76	64	94	138	51	76	88
Loc. 3	114	112	110	112	86	84	87	85	69	87	141	52	85	104
Loc. 4	121	119	116	119	96	94	98	96	80	92	151	59	101	115
Loc. 5	114	112	109	111	97	95	99	97	80	95	133	70	91	94
Loc. 6	119	116	114	116	103	100	105	102	86	97	141	72	100	100

Source: own composition based on simulations with the Freight model Flanders

4.5 General conclusions

The impacts simulation described in CHAPTER 4 is a logical step in the methodology and provides inputs for the next step in the research – cost-benefit analysis. The inputs are in the form of origin-destination tonkilometre matrixes for the scenario runs and contain impacts of each of the scenario on the cargo flows. In the cost-benefit analysis, described in CHAPTER 5, those matrixes are used for calculating the costs and benefits for the society that are caused by the innovation.

Running the scenarios in the freight model allows determining the impacts of the policy innovations. In addition to scenario-specific interpretations that were already described above, some general observations from the scenario runs should be outlined:

- The results of the simulations show that combinations of measures with similar consequences have greater effect. This is clearly demonstrated by scenarios 8, 11 and 12 where a set of combined policy measures are enacted. Therefore for practical implementation a combination of measures is more advisable.
- One scenario may have different effect (even adverse) on the traffic volumes in different points and directions of the road network.
- Scenarios with port growth variations clearly show the impacts of port turnover dynamics on the traffic on the points on the motorway E313. The increased/decreased port throughput has an influence both on incoming and outgoing flows, but the level of effect is different. The incoming flows are influenced less than the outgoing flows. For example, in matrix 8 (in the direction of Antwerp) the assumptions of scenarios 4 to 7 influence the goods flow less than in matrix 7 (same point, in the direction away from Antwerp).
- In all regions the scenarios introducing the extra measure for inland navigation (scenarios 2, 3, 5 and 7) do not seem to significantly influence the mode choice (expressed in percentages). Moreover, the same effect is observed in the scenarios for which a moderate policy is assumed (scenarios 4, 5, 6 and 7).

From the scenarios that were investigated, the scenario 4 seems to be the most likely to be considered by the government for practical implementation in Belgium. Therefore this scenario is selected for further investigation as a case study in this research. It is described in detail in the next chapter (CHAPTER 5, subchapter 5.1).

CHAPTER 5 Cost-benefit analysis of innovative process

5.1 The selected case study

As mentioned in the conclusions of the previous chapter, the scenario 4 from the modeling was chosen for further investigation as the most likely scenario to be considered by the Belgian government for practical implementation.

The case deals with introduction of road pricing for heavy goods vehicles on the Belgian motorway network. The price for using the motorway network for heavy goods vehicles is set to 0.15 €/km¹⁹ for the use of highways in Belgium and it replaces the circulation tax and Euro-vignette. For the neighboring countries, it is assumed that in The Netherlands and Luxembourg similar pricing conditions are introduced. In Germany and France, the current pricing environment²⁰ is assumed to stay in place.

For other modes, for rail the scenario assumes that a higher user fee will be introduced at 1.67 €/train-km²¹. For inland navigation, the continuation of current policies is assumed.

It is assumed that the government (which could be a body or a company created by the government or a private partner under concession agreement) in this case is the innovator that develops and introduces the required infrastructure on the road network. This entity also bears the cost related to the development of the system. The road transport companies (road users), to be able to use the motorway network and pay the user fee, are required to equip each heavy goods vehicle with an onboard unit, similar to those in use in other countries.

5.2 The cost-benefit approach

The situation of introduction of road pricing is shown in Figure 21. On vertical axis is the price of transportation P and on horizontal axis is the transport quantity Q . The initial transport demand, before introduction of road pricing, is shown by curve D_0 . Before the introduction of road pricing the transport quantity Q_0 would be used at the price of P_0 .

As the road pricing is introduced the quality of the road increases, because of travel time savings which the road users gain. This shifts the demand curve upwards by an amount s , giving a new demand curve D_1 . At the same time, the price is increased from P_0 to P_1 and that changes the transport quantity from Q_0 to Q_1 .

To evaluate the impacts of the road pricing, the cost-benefit approach compares the initial social benefit $B_0E_0Q_0O$ to the social benefit after introduction of the innovation $B_1E_1Q_1O$, shown in Figure 21. The shaded area Y shows the total value of quality improvement, including a part of the value that road users transmit to the operator as toll. The total toll that is collected is $P_1E_1FP_0$. And the shaded area Z shows the loss that is brought by the introduction of road pricing.

Because the shape of the demand curve is not known²², in this research it is assumed that the demand curve is linear. Using an estimation of elasticity of road freight transport the initial

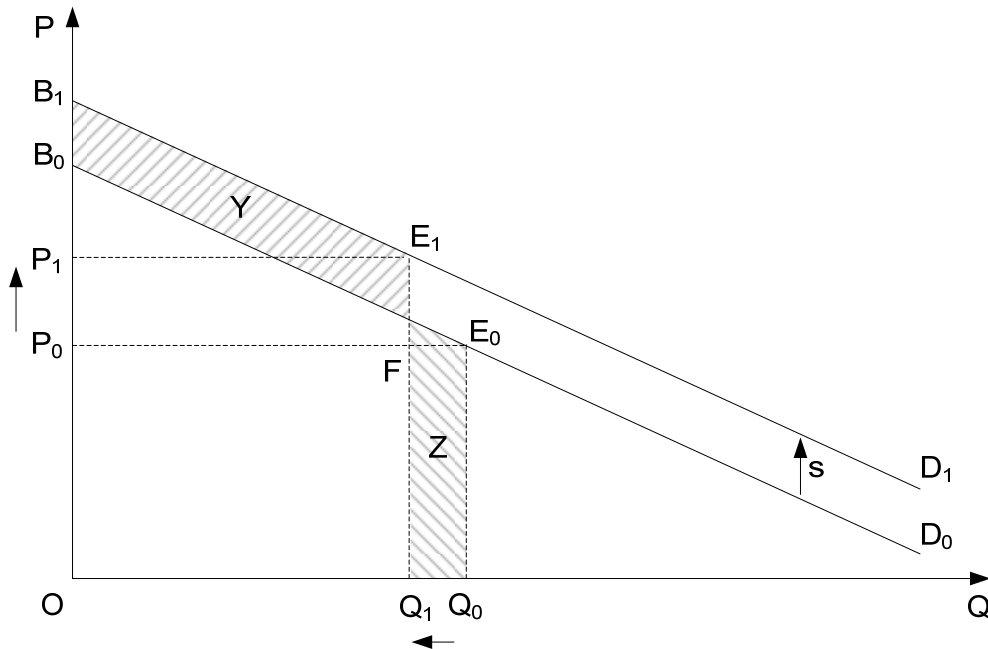
¹⁹ In prices of 2004, the start year of the project.

²⁰ The system of Péage in France and LKW-maut in Germany.

²¹ In 2007 it was 1.63 €/train-km.

consumer surplus is calculated as the area of triangle $P_0E_0B_0$ and the new consumer surplus as the area of triangle $P_1E_1B_1$. The impact of road pricing on consumer surplus can be calculated by subtracting one from another. It must be noted that the slope of D_1 can be different from that of D_0 , because it varies with both price and quantity²³.

Figure 21: Benefits of introducing road pricing



Every actor or individual that is impacted on by the implementation of a policy measure is different. The costs and benefits the actor faces will be different. This is taken into account when constructing the structure for the cost benefit analysis for the case study dealing with a measure tackling congestion on port hinterland links.

The following Table 20 composes the structure of main costs and benefits grouped by the different actors involved.

²² According to Blauwens *et al.* (2008), in reality a demand curve can be convex or concave.

²³ For a linear demand curve the price elasticity of demand is calculated: $E_d = \alpha \frac{P}{q}$, where E_d is the elasticity, α is the slope, p is the price and q is the quantity; Boardman *et al.* (2001), p.309.

Table 20: Actors, their direct costs and benefits

Actor/CBA component	Benefit	Cost
Government (the innovator)		
System development		X
System operation		X
Tolls	X	
Companies (road users)		
Equipment (onboard unit or similar)		X
Tolls		X
Time	X	
Consumer surplus	X	
Individuals		
Time	X	
Externalities	X	

It is important to note that the toll revenues for the government and toll costs for the road users are listed as costs or benefits in Table 20, because of the setting of the problem. Usually in the literature the distribution amongst the actors is not important. Therefore the transfers between the different actors are not included as the impacts of the project. And as transfers the change in tax revenues (excise duties and VAT) is not taken into account.

According to the methodology section 3.2.2, the cost components are grouped to fit the two sides of the cost benefit equations:

- Industrial-economic side, and the
- Welfare-economic side.

To recall section 3.2.5, the success of the innovation is achieved if the following is true:

$$\begin{cases} \Delta R_p - \Delta C_p + S_p > x \\ \Delta B_s - \Delta C_s + S_s > y \end{cases}$$

where ΔR_p are changes of the revenue an innovation inflicts for the innovator;

ΔC_p are changes in costs innovation inflicts for the innovator;

ΔB_s are changes in benefits side for the society because of the innovation;

ΔC_s are changes in costs related to introduction of innovation for the society.

For the case in focus, based on Table 20, an overlay of the values for the formula are given in Table 21. It can be seen that the costs, ΔC_p and ΔC_s are to be paid by the government and the companies that are road users. And the benefits, ΔB_s , are enjoyed by the individuals and the companies that are road users.

Table 21: Actors, their direct costs and benefits

Actor/CBA component	Benefit	Cost
Government (the innovator)		
System development	ΔR_p	ΔC_p
System operation		
Tolls		
Companies (road users)		
Equipment (onboard unit or similar)	ΔB_s	ΔC_s
Tolls		
Time		
Consumer surplus		
Individuals		
Time		
Externalities		

For the case investigated, the costs and benefits of the project arise in different periods of the life of the project. For those numeric values of costs and benefits to be comparable, the costs and benefits of the project have to be discounted to a common metric – the present value.²⁴ After doing that, the costs and benefits can be valued using net present value, to test the outcome and determine which of the situations defined in 3.2.5 will occur and which path it will follow in the success algorithm, Figure 7 on page 51.

5.3 Quantification

Here the quantification of the inputs done based on trusted literature sources is described. The values mentioned in those sources are reported, but it is evident that for calculations those values are discounted to the start year of the project.

5.3.1 System development and operation costs, toll revenues

The cost of system development and maintenance can be estimated based on the known figures for the system development costs abroad.

For the LKW-MAUT system in Germany the estimated system development cost was approximately 700 million €²⁵ for the system covering 12 000 km of German autobahn for all trucks with a maximum weight of 12t and above.

The development cost for the Austrian GO toll system in 2004 was 350 million €.²⁶ The Austrian systems annual operation costs in 2007 have been 9.7% of the revenues²⁷ of 984 million €, which makes 95.5 million €. The total length of the Austrian motorway network is

²⁴ Anthony *et al.* (2006)

²⁵ Net Resources International (2005)

²⁶ Rajnoch (2009)

²⁷ Walzl (2008)

1699 km. However, Replogle (2006) reports annual system operation costs for the German system in 2005: 585 million €, and for the Austrian system in 2004: 33 million €.

An assumption for the system development costs in Belgium can be made. Of course, it should be taken into account that a part of the system development costs is fixed cost, and a part is network-depending. Belgium is a smaller country than Germany or Austria and certain technologies and experience could be bought from those countries. For the cost-benefit analysis it is assumed that the system development costs for 1763 km²⁸ of Belgian road network will be 150 million € and the annual operation costs will be 15 million €.

Based on the modeling results, and the assumptions of the kilometre price in the scenario of 0.15 €/km the toll revenues are estimated.

5.3.2 Equipment cost

The experience of other countries shows that the cost of the equipment for the road transport operator is not substantial.

From 1 September 2011 Germany and Austria have introduced an interoperable on-board unit TOLL2GO. The on-board unit costs 5 EUR. The installation costs are approximately 50-70 € (2 man-hours). The same applies for the German on-board unit. If the non-interoperable Austrian GO-box is chosen, there is the 5 € cost of the unit, but no installation cost to the company, because it can be attached to the windscreen by the driver using double-sided tape.²⁹

If a GPS-based on-board unit will be chosen for road pricing in Belgium, it can be assumed that the equipment costs to the haulier will be 55-75 €/truck. If DSRC (dedicated short range communications) system, like in Austria, is chosen, then the costs to the road transport operators could be 5 €/truck.

For quantification purposes it is assumed that Belgium introduces the DSRC-based system and costs per truck to the haulier are 5 €.

It can be estimated that 55 thousand trucks with Belgian registration will be equipped with the onboard units, which makes the total cost for the Belgian operators 275 thousand €. The equipment costs of foreign road transport operators are not taken into account, because they could possibly already have an interoperable on-board unit, and are assumed not to have direct influence on the decisions in Belgium.

5.3.3 Time cost

Time costs are the costs that arise to the company due to the passing of time. For a company owning a truck those include interest and depreciation, insurance, road taxes, drivers wages and other costs. Blauwens *et al.* (2008) report the time cost of 24.18 €/hour³⁰ for a tractor vehicle with semitrailer.

²⁸ Source: OECD

²⁹ <http://www.toll-collect.de>, <http://www.asfinag.at>

³⁰ In prices of 2004.

Individuals also experience a cost due to passing of time. Based on multiple studies Shires and de Jong (2009) report the value of travel time savings for individuals for various countries. For Belgium a value³¹ of 9.82 €/hour is reported for commuter travel and 7.88 €/hour for other travel. Therefore, for analysis a value of 9 €/hour is chosen. Based on Adra *et al.* (2010), the occupancy rate of 1.1 passenger/vehicle for passenger vehicles is used.

Maerivoet and Yperman (2008) report congestion curves for regions of Belgium, as well as parameter values for those. This data is used for calculating the impact on travel time seeing the reduction of the number of heavy goods vehicles on the network in comparison with the base scenario. One heavy goods vehicle is counted as two passenger vehicles.

The formula used:

$$T = T_{ff} \left(1 + \alpha \left(\frac{q}{C} \right)^\beta \right),$$

where:

- T_{ff} = the travel time in free flow,
- q = traffic volume (vehicle-kilometres per hour),
- C = maximal traffic volume (vehicle-kilometres per hour),
- α = constant,
- β = constant.

Table 22 gives the values used for calculation.

Table 22: Overview of parameter values for congestion function for Belgian regions

Region	T_{ff} (seconds)	C (vehicle-km)	α	β
Flanders	36.32	4 158 000	0.1254	1.6002
Wallonia	34.59	2 185 800	0.0748	1.0000
Brussels	33.90	16 334	0.3300	1.2385
Agglomeration of Antwerp	35.81	346 667	0.1507	1.5600
Agglomeration of Gent	36.85	222 827	0.0694	1.5298
Agglomeration of Luik	35.56	192 913	0.0469	1.5515

Source: Maerivoet and Yperman (2008), page 18

The modeling results show that, if the road pricing is introduced, the volume of the road freight traffic decreases by 151 million tonkilometres. Such decrease of freight traffic, based on formulas above, could result in time savings of 0.327 million hours/year for road operators and 1.23 million hours/year for individuals.

5.3.4 Externalities

For the three hinterland transport modes investigated in the case study there are different levels of externalities. For quantification purposes the data of Handbook on Estimation of External Costs in the Transport Sector is used, CE Delft *et al.* (2008).

³¹ In prices of 2003.

For road transport CE Delft *et al.* (2008) report a range of values from 1.66 €/tkm (for day-time interurban traffic) to 1.74 €/tkm (night-time interurban traffic). In this research the value of 1.68 €/tkm is chosen.

For rail CE Delft *et al.* (2008) suggest a range of values for externalities from 0.31 €/tkm (for day-time interurban electric-powered trains) to 0.39 (for night-time interurban electric-powered trains). For diesel-powered trains the range for day and night time is reported from 1.24 – 1.32 €/tkm, but since the diesel-powered trains on the Belgian network in 2010 have done 27%³² of the train-kilometres, the value of 0.59 €/tkm is used.

For inland waterway transport CE Delft *et al.* (2008) report a vast range of 105-1482 €/ship-km, and with average load factor for dry cargo of ~80%³³, for an average ship used on Belgian waterways the external costs would be 0.25 €/tkm.

5.3.5 Social discount rate

A debate among economists exists³⁴ over the appropriate social discount rate to be used for calculation of net present value for a project. Cruz Rambaud and Munoz Torrecillas (2006) describe different possible options. For the purpose of this cost-benefit analysis the real discount rate of 4.5% is chosen.

5.3.6 Elasticity

Litman (2013) gives an overview of several sources investigating price elasticity of freight transport. The values of the price elasticity cited range from -0.04 to -2.97. For the purpose of this research a value for price elasticity of road freight traffic (measured in truck-kilometers) used is -2.

5.4 Calculation results

5.4.1 Cost-benefit analysis

The economic analysis of the case study is presented in the Table 23. The vertical axis of the table lists the costs and benefits, and the horizontal axis of the table presents the time in years.

³² Based on NMBS and Federaal Planbureau.

³³ Own calculation based on Beelen (2011).

³⁴ Anthony *et al.* (2006)

Table 23: Costs and benefits of the road pricing case study, million €

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	...
BENEFITS																
Government																
Tolls	0	268.631	272.03	275.429	278.828	282.226	285.625	289.024	292.423	295.822	299.221	302.62	306.018	309.417	312.816	...
Companies																
Time	0	7.90985	8.1076	8.31029	8.51805	8.731	8.94927	9.17301	9.40233	9.63739	9.87832	10.1253	10.3784	10.6379	10.9038	...
Consumer surplus	0	66.3081	66.9561	67.6042	68.2523	68.9003	69.5484	70.1965	70.8446	71.4926	72.1407	72.7888	73.4368	74.0849	74.733	...
Individuals																
Externalities (road)	0	2.54	2.60003	2.66503	2.73166	2.79995	2.86995	2.94169	3.01524	3.09062	3.16788	3.24708	3.32826	3.41146	3.49675	...
Time	0	12.183	12.4876	12.7998	13.1198	13.4478	13.784	14.1286	14.4818	14.8438	15.2149	15.5953	15.9852	16.3848	16.7944	...
TOTAL BENEFITS	0	357.569	362.181	366.808	371.449	376.106	380.777	385.464	390.167	394.886	399.623	404.376	409.147	413.936	418.744	...
COSTS																
Government																
System development (investment)	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...
System operation	0	15	15.375	15.7594	16.1534	16.5572	16.9711	17.3954	17.8303	18.276	18.7329	19.2013	19.6813	20.1733	20.6777	...
Companies																
Equipment (on-board unit or similar)	0.275	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	...
Tolls	0	268.631	272.03	275.429	278.828	282.226	285.625	289.024	292.423	295.822	299.221	302.62	306.018	309.417	312.816	...
Individuals																
Externalities (IWW)	0	0.10689	0.10956	0.1123	0.11511	0.11799	0.12093	0.12396	0.12706	0.13023	0.13349	0.13683	0.14025	0.14375	0.14735	...
Externalities (rail)	0	0.11282	0.11564	0.11853	0.12149	0.12453	0.12764	0.13083	0.1341	0.13746	0.14089	0.14442	0.14803	0.15173	0.15552	...
TOTAL COSTS	150.275	283.906	287.685	291.474	295.273	299.081	302.9	306.729	310.569	314.421	318.283	322.157	326.043	329.941	333.852	...
NET BENEFITS	-150.275	73.6628	74.4962	75.3341	76.1768	77.0244	77.8769	78.7346	79.5975	80.4657	81.3395	82.2189	83.1041	83.9952	84.8924	...

Table 23: Costs and benefits of the road pricing case study, million € (continued)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
BENEFITS															
Government															
Tolls	316.215	319.614	323.013	326.411	329.81	333.209	336.608	340.007	343.406	346.805	350.203	353.602	357.001	360.4	363.799
Companies															
Time	11.1764	11.4558	11.7422	12.0358	12.3367	12.6451	12.9612	13.2852	13.6174	13.9578	14.3068	14.6644	15.031	15.4068	15.792
Consumer surplus	75.381	76.0291	76.6772	77.3253	77.9733	78.6214	79.2695	79.9175	80.5656	81.2137	81.8617	82.5098	83.1579	83.806	84.454
Individuals															
Externalities (road)	3.58417	3.67377	3.76562	3.85976	3.95625	4.05516	4.15654	4.26045	4.36696	4.47614	4.58804	4.70274	4.82031	4.94082	5.06434
Time	17.2143	17.6447	18.0858	18.5379	19.0014	19.4764	19.9633	20.4624	20.974	21.4983	22.0358	22.5867	23.1513	23.7301	24.3234
TOTAL BENEFITS	423.571	428.417	433.283	438.17	443.078	448.007	452.959	457.932	462.93	467.95	472.996	478.066	483.162	488.284	493.432
COSTS															
Government															
System development (investment)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
System operation	21.1946	21.7245	22.2676	22.8243	23.3949	23.9798	24.5792	25.1937	25.8236	26.4692	27.1309	27.8092	28.5044	29.217	29.9474
Companies															
Equipment (on-board unit or similar)	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
Tolls	316.215	319.614	323.013	326.411	329.81	333.209	336.608	340.007	343.406	346.805	350.203	353.602	357.001	360.4	363.799
Individuals															
Externalities (IWW)	0.15103	0.15481	0.15868	0.16264	0.16671	0.17088	0.17515	0.17953	0.18402	0.18862	0.19333	0.19817	0.20312	0.2082	0.2134
Externalities (rail)	0.15941	0.16339	0.16748	0.17166	0.17596	0.18035	0.18486	0.18949	0.19422	0.19908	0.20406	0.20916	0.21439	0.21974	0.22524
TOTAL COSTS	337.775	341.711	345.661	349.625	353.603	357.595	361.602	365.625	369.663	373.716	377.787	381.874	385.978	390.1	394.24
NET BENEFITS	85.7959	86.7057	87.6221	88.5451	89.4751	90.4121	91.3563	92.3079	93.2671	94.2341	95.209	96.1922	97.1837	98.1837	99.1926

Also, the following values of net present value (NPV), internal rate of return (IRR), benefit/cost (B/C) ratio and return on investment (ROI) were calculated, see Table 24. The net present value, internal rate of return and benefit/cost ratio show positive social impact of the road pricing scenario. The impacts of variations in certain parameters on the outcomes of the project are investigated in the subchapter 5.4.3.

Table 24: Calculated parameters

NPV =	1184.383 m€
IRR =	50.14 %
B/C ratio =	1.22
ROI =	789.6 %

5.4.2 Success conditions

To recall section 3.2.5 again, the success of the innovation is achieved if the following is true:

$$\begin{cases} \Delta R_p - \Delta C_p + S_p > x \\ \Delta B_s - \Delta C_s + S_s > y \end{cases}$$

The benefits ΔB_s of the innovation are enjoyed by the companies and individuals, which both gain time savings. In addition to that the individuals get the benefits of reduced externalities from the reduction of road freight transport. The benefits for companies include change in consumer surplus. The costs ΔC_p of introducing and maintaining the road pricing system are covered by the government from the tolls collected that are paid by the companies (road users). Also, a small part of the costs ΔC_s related to equipping of the vehicles is covered by the road freight operators. This distribution is shown in Table 21 above. As described in section 3.2.5, x and y are threshold values that are required in order to continue the innovation process.

Having calculated the values of those variables, they can be inserted in the equation discounted for the value at the beginning of the project.

Table 25: Success conditions, m €

Actor/CBA component	Benefit	Cost	
Government (the innovator)			
System development	ΔR_p	ΔC_p	
System operation			150
Tolls			321.766
Total for innovator	4902.964	471.766	
Companies (road users)			
Equipment (onboard unit or similar)	ΔB_s	ΔC_s	
Tolls			1.156
Time			4902.964
Consumer surplus			169.675
			1176.591
Individuals			
Time	ΔB_s	ΔC_s	
Externalities			261.339
	54.413	4.713	
Total for public	1662.018	4908.833	
TOTAL	6564.982	5380.599	
NET BENEFIT	1184.383		

It is clear that the success conditions in Table 25 correspond with the situation b.1 of the methodology:

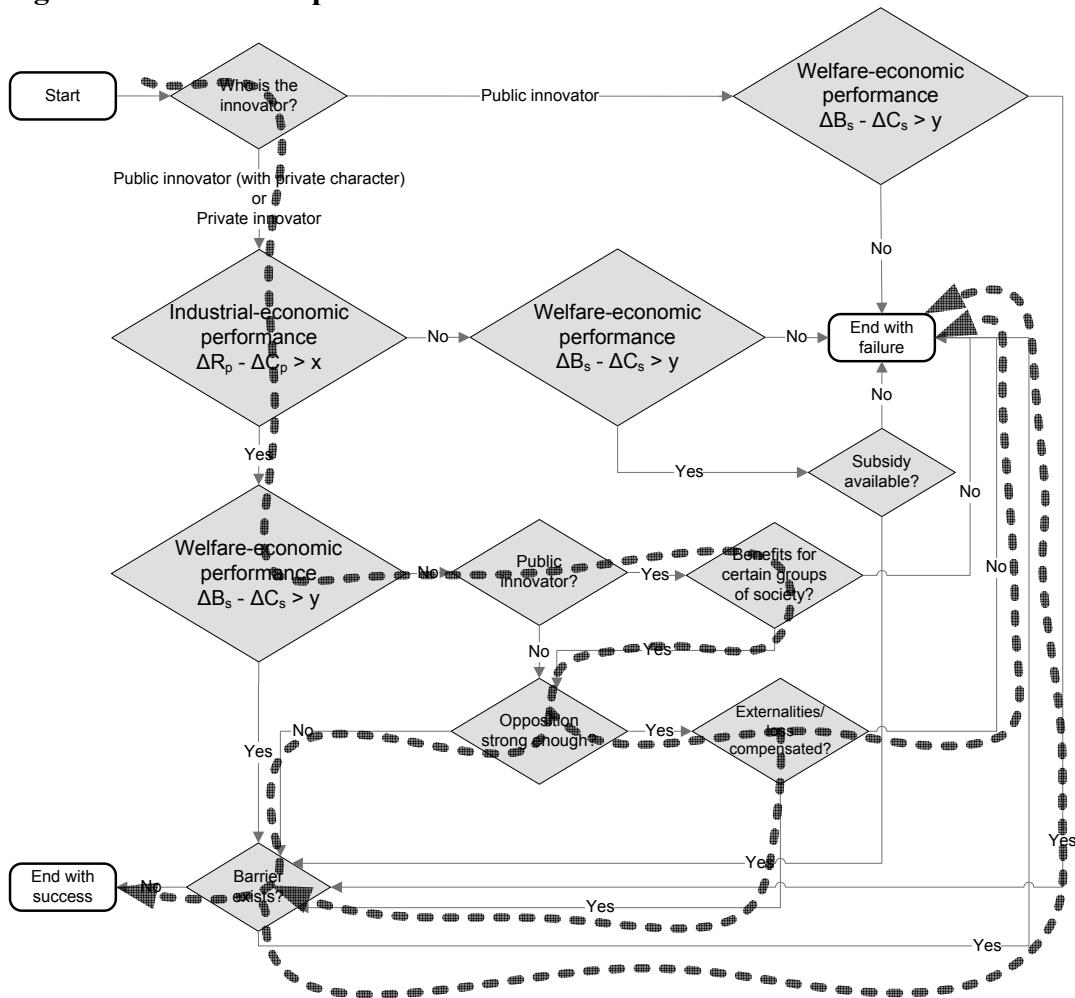
$$\begin{cases} \Delta R_p - \Delta C_p > x \\ \Delta B_s - \Delta C_s < y \end{cases}$$

Here the financial outcomes are positive for the innovator – government or agency which would be implementing the road pricing system. Also, the outcomes of the innovation are highly positive to the individuals. The time savings and consumer benefit do not outweigh the toll cost for the companies, therefore dissatisfaction of this actor can be expected.

In this case the innovation will most likely proceed, because government is the innovator and also the one capable of stopping the innovation. The positive impact on the benefit for the voters might play a role to continue with the innovation and ignore the opposition from commercial road users.

If the barriers do not exist or are not created by the companies that are road users (for freight), for this innovation the chance of being adopted is high. The possible innovation paths in this case are shown in Figure 22.

Figure 22: Innovation path



5.4.3 Sensitivity analysis

The sensitivity analysis has been conducted to determine the impacts of changes in the most important factors of the cost-benefit analysis:

- 1) the value of time;
- 2) the discount rate;
- 3) the outputs of the freight model.

1) The impact of changes in the value of time has been tested on the main calculated parameters in the amplitude of $\pm 50\%$. The impacts the change would have on the NPV (Figure 23), IRR (Figure 24), B/C ratio (Figure 25) and ROI (Figure 26) are shown. In the graphs on the horizontal axis the change in the value of time is shown, for example, -0.2 means a 20% reduction of the value of time. On the vertical axis the NPV, IRR and B/C ratio is displayed.

Figure 23: Impact of time value change on NPV at different discount rate values

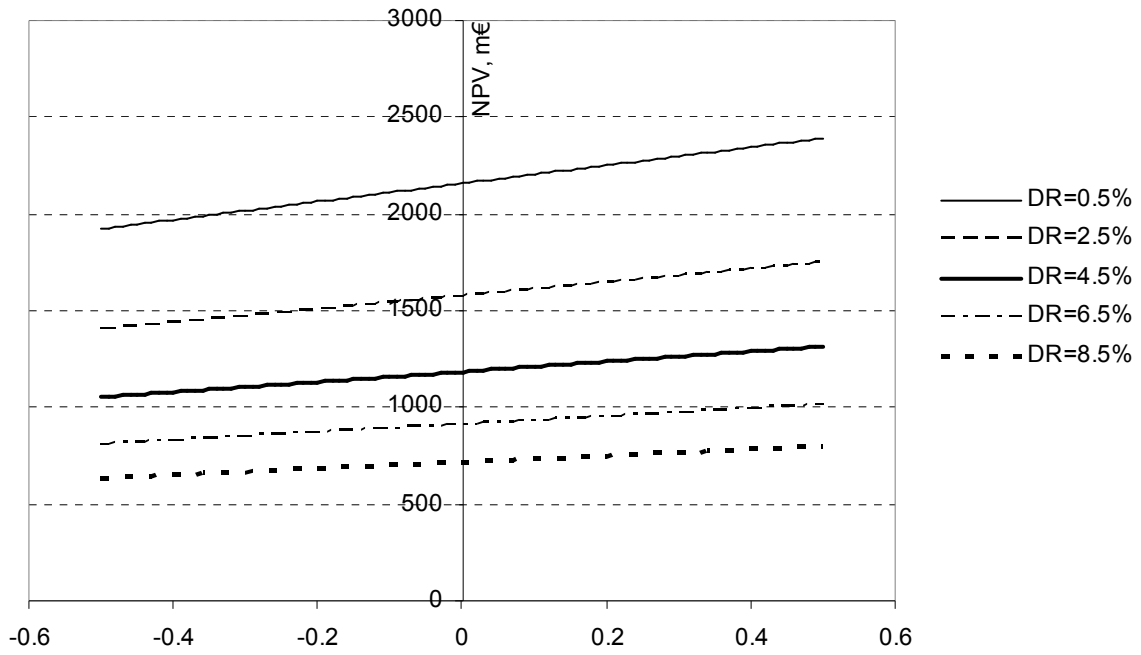


Figure 24: Impact of time value change on IRR, at discount rate of 4.5%

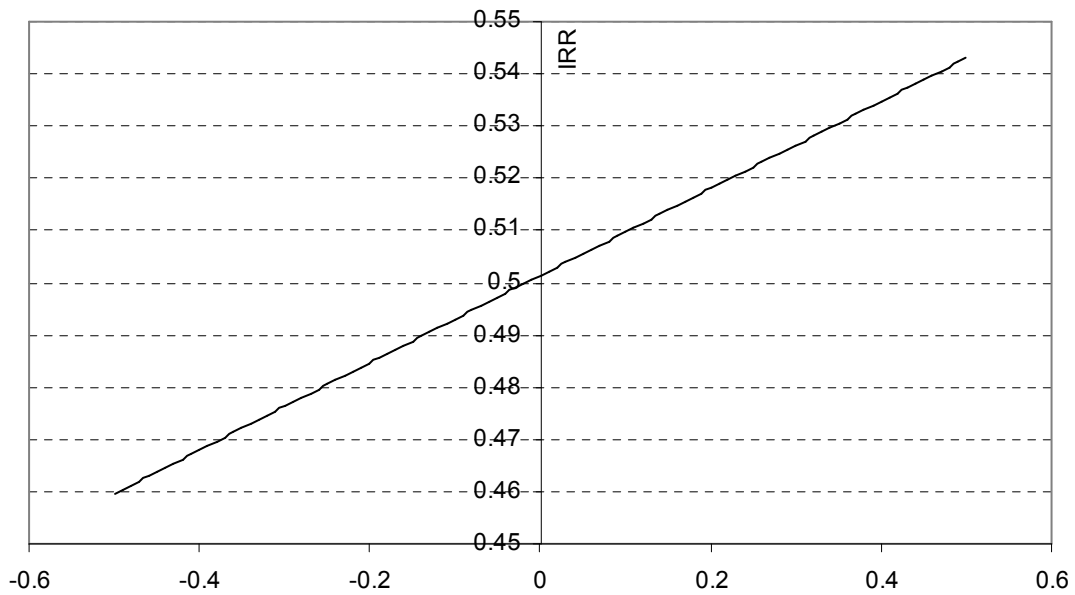


Figure 25: Impact of time value change on B/C ratio, at discount rate of 4.5%

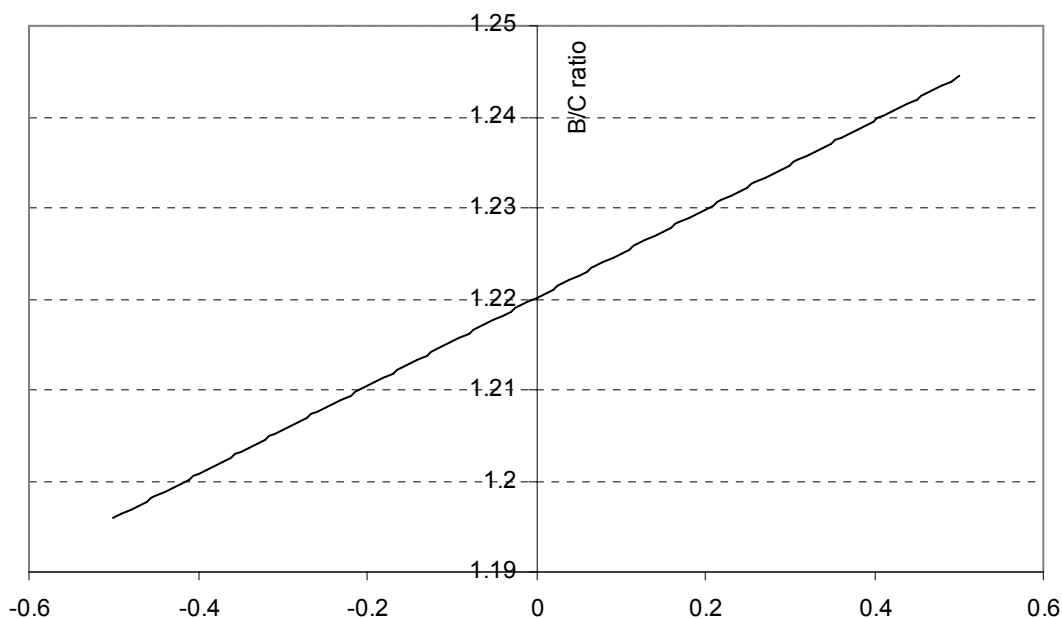
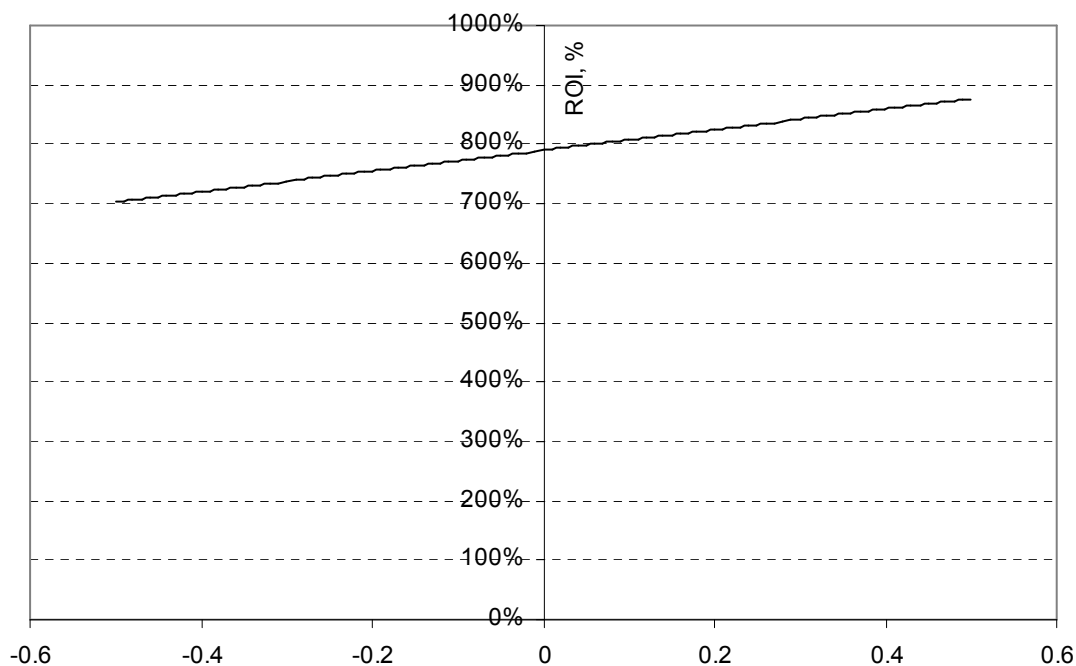


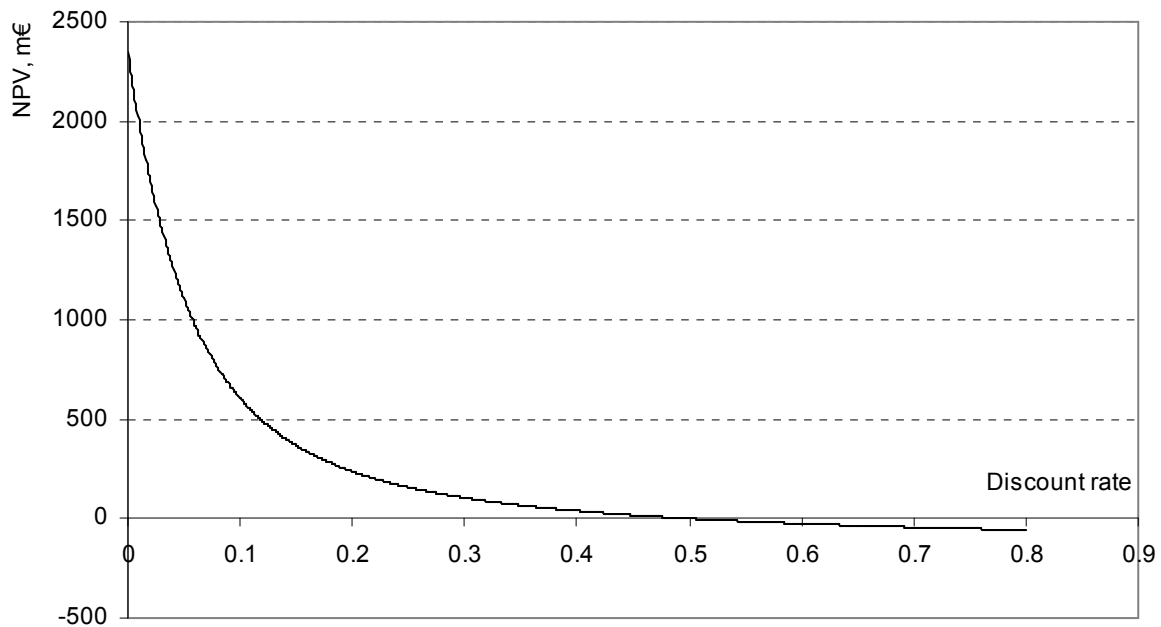
Figure 26: Impact of time value change on ROI, at discount rate of 4.5%



From the figures it is clear that changes in the value of time can incur changes to the calculated parameters, which could make the proposed road pricing scenario less or more favoured. If the time values for companies and individuals were to rise, the impacts of the pricing scenario would increase the NPV, IRR, B/C ratio and ROI as shown in the graphs above.

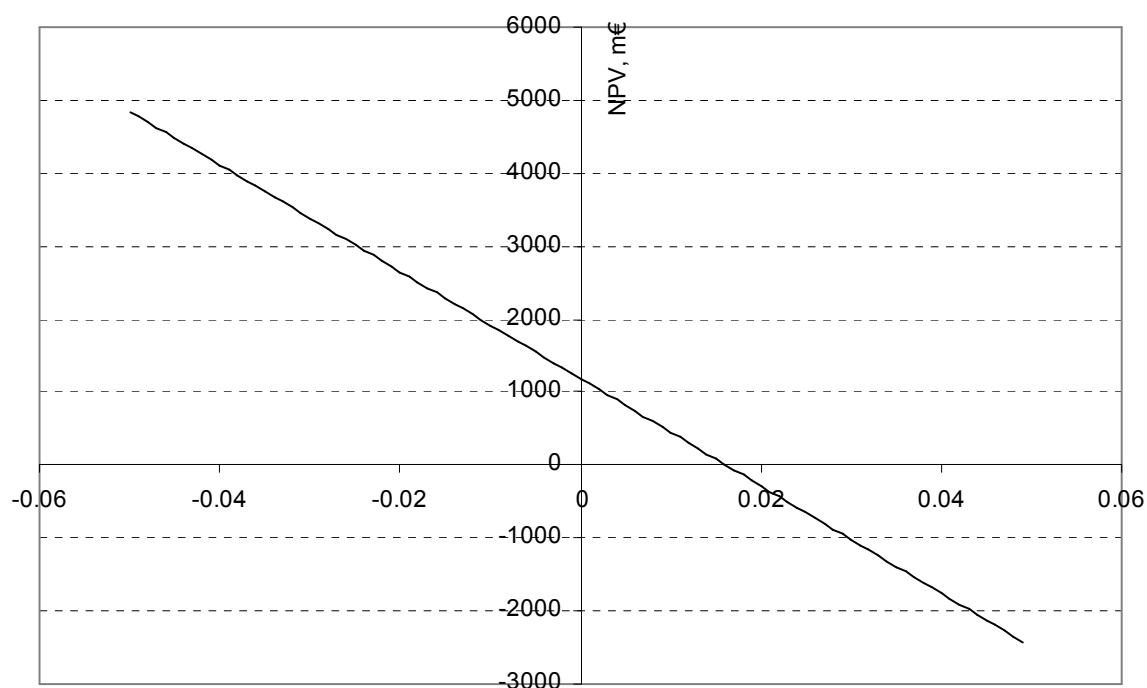
2) The second important aspect to consider is the impact of the discount rate on the valuation of the innovation. Figure 27 below shows this impact of it on the NPV. As the discount rate increases, the NPV decreases. At the discount rate level of ~50% the NPV for the project becomes 0 and above that the NPV becomes negative.

Figure 27: Impact of discount rate on NPV



3) In real life the outcomes of a pricing measure deviate from what the results of the modeling are. The impacts of those deviations are shown in Figure 28.

Figure 28: Impact of modeling output on NPV



The vertical axis shows NPV in million € and the horizontal axis shows the percentage (0.01 = 1%). For example, if the impacts of the pricing scenario were underestimated by a certain percentage (to the left from the vertical axis), the NPV of the project would be higher. The impacts of the modeling outputs can be substantial: a 1% change in the results (in tkm) corresponds to 734.1 m€ change in the NPV.

5.4.4 Financial analysis

The project performance is evaluated from the economic side and the project is clearly preferable for the innovator. For the government as the decision maker, it is also interesting to look in detail at the financial outcomes of the introduction of the road pricing scenario.

Table 27 shows the financial results of the project with estimated user charge revenues and system development and maintenance costs.

The following values of net present value (NPV) and return on investment (ROI) have been calculated, see Table 26. The positive net present value and return on investment show that the project might be interesting to the government also because of the positive financial outcomes. It must be noted that the purpose of road pricing policies usually is not the financial results of the project, but other goals that are reached through the policy, e.g. reduction of congestion.

Table 26: Calculated parameters

NPV =	4431 m€
ROI =	2954 %

Table 27: Financial results of the project

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	...
REVENUES																
Tolls	0	268.6	272	275.4	278.8	282.2	285.6	289	292.4	295.8	299.2	302.6	306	309.4	312.8	...
TOTAL INFLOWS	0	268.6	272	275.4	278.8	282.2	285.6	289	292.4	295.8	299.2	302.6	306	309.4	312.8	...
COSTS																
System development (investment)	150															
System operation		15	15.38	15.76	16.15	16.56	16.97	17.4	17.83	18.28	18.73	19.2	19.68	20.17	20.68	...
TOTAL OUTFLOWS	150	15	15.38	15.76	16.15	16.56	16.97	17.4	17.83	18.28	18.73	19.2	19.68	20.17	20.68	...
NET CASH FLOW	-150	253.6	256.7	259.7	262.7	265.7	268.7	271.6	274.6	277.5	280.5	283.4	286.3	289.2	292.1	...

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
REVENUES																
Tolls	...	316.2	319.6	323	326.4	329.8	333.2	336.6	340	343.4	346.8	350.2	353.6	357	360.4	363.8
TOTAL INFLOWS	...	316.2	319.6	323	326.4	329.8	333.2	336.6	340	343.4	346.8	350.2	353.6	357	360.4	363.8
COSTS																
System development (investment)	...															
System operation		21.19	21.72	22.27	22.82	23.39	23.98	24.58	25.19	25.82	26.47	27.13	27.81	28.5	29.22	29.95
TOTAL OUTFLOWS	...	21.19	21.72	22.27	22.82	23.39	23.98	24.58	25.19	25.82	26.47	27.13	27.81	28.5	29.22	29.95
NET CASH FLOW	...	295	297.9	300.7	303.6	306.4	309.2	312	314.8	317.6	320.3	323.1	325.8	328.5	331.2	333.9

5.4.5 Conclusions

In CHAPTER 5, the application of the cost-benefit analysis for determining the outcomes of the innovation, the road pricing scenario, was performed. The analysis showed positive net benefits of the project, which is an indicator for high likelihood for this innovation to succeed. However, negative impacts for an important actor, companies that use the roads for heavy goods transport, become obvious. This is the actor to expect opposition from during the innovation process.

The analysis shows that most benefits are enjoyed by the individuals. Those come from time savings and reduction of externalities related to cargo traffic volumes. For companies that are road users the benefits come from time savings and consumer surplus, but those do not outweigh the toll that has to be paid.

In relation to the introduction of the system, most of the costs are paid by the government as the innovator and the decision maker. Of course, those costs would be recovered through the toll collected. The costs related to equipping the vehicles are covered by the companies that pay the toll.

In the cost-benefit analysis, an important factor seems to be the value of time. At reduced values of time, the outcomes of the cost-benefit analysis become less positive. However, a decrease of the values of time is unlikely. Sensitivity analysis shows that an increase of value of time can substantially improve the results of the cost-benefit analysis.

Another important influencing factor for the cost-benefit is the impact of the discount rate used. In the sensitivity analysis this was tested. The outcomes of the project are positive at the values of the discount rate used, but become negative as the discount rate is increased above ~50%.

The modeling outputs can have substantial impacts on the results of the cost-benefit analysis and consequently on the decisions taken. Therefore, great care should be taken to ensure the accuracy of the modeling results.

For the government as the innovator and the decision maker, the cash flows of the project are important. Therefore, the financial analysis of the project for the innovator, taking into account the revenues from user charges, was done. It shows that the financial side of the project is beneficial for the innovator.

CHAPTER 6 Systems Innovation analysis

As mentioned earlier, the methodology of this research uses a three-stage approach. As the last stage of the methodology, to further contribute to the results of the cost-benefit approach, the Systems Innovation (SI) methodology is used. This is a way to go a step further and add richness to the analysis by determining the success conditions of the innovation in focus of this research (case study described in subchapter 5.1).

In the Systems Innovation (SI) approach, an innovation is perceived as an interactive and nonlinear process, which involves a variety of actors and institutions. By focusing on interactions between these actors and institutions, the SI approach allows identifying combinations that lead to innovation success or failure. The approach is described in detail in subchapter 3.3 of the methodology chapter.

In this research the SI approach is applied in two steps. First, the investigation of several case studies is done (in subchapter 6.1 below). All the case studies are in the field of surface transport. These cases were investigated as part of the EU-financed research project InnoSuTra and include four cases investigated by the author of this research. To recall section 1.8.4, the cases are listed in Table 28 below.

Table 28: InnoSuTra cases analysed

	Road	Rail	Maritime	IWW	Intermodal
Technological	ITS: Variable Speed Limits (VSL)*		Cold ironing	Air lubrication of ships	Port Community System (PCS)
			Reefer containerisation	Information Technology in the inland navigation industry	Superfast Ferries (SFF)
Organizational		Eurotunnel	Indented berth	Available capacity on small IWW	Freight Villages (FV)
Policy	Eurovignette Directive*		Port State Control (PSC)		Internalization of external costs
	ECMT three trips limit*				European Intermodal Loading Unit
	EU Cabotage*				

*investigated by the author of this research, for detailed analysis see subchapter 6.1 below on case studies investigated.

Source: based on own research and Arduino *et al.* (2011a)

Second, based on the outcomes of the SI case study analysis, the resulting mapping is applied to the innovation case investigated to determine the areas where the actions taken would ensure successful market take-up of the innovation.

6.1 Case studies investigated

6.1.1 Case 1 – EU International road transport market liberalization: cabotage

6.1.1.1 The case

Background and development

The history of the cabotage of road transport in the EU dates back to the Treaty of Rome of 1957, when it was specifically mentioned in the Article 75.1 (b).

It has taken several decades until cabotage was first introduced on 1 July 1990 under Council Regulations (EEC) Nr. 4059/89. This system was introduced under a quantitative restriction (quota) system on cabotage transport through a system of granting authorisations. The authorisations were issued in limited quantities and each authorisation allowed the haulier to perform an unlimited number of cabotage trips within a time period of one or two months. The authorisation could be transferred between different vehicles of the same haulier.

Already in 1992, the intra-Benelux cabotage was liberalized completely. But the cabotage regime was extended to the EFTA countries on 1 July 1994 with the exception of Austria, which joined on 1 January 1997, and Switzerland.

A Commission report on the application of the cabotage quota scheme (COM/98/0047) showed that, although the number of quotas increased annually, these quotas were largely underused and had not attracted ‘unscrupulous’ operators into specific national markets.

In accordance with article 12 of Council Regulation No 3118/93 of 25 October 1993, most cabotage restrictions have been lifted since 1 July 1998 in the 15 Member States of the European Union. From that date onwards, Regulation No 3118/93 on freight transport cabotage stipulates that any non-resident carrier who is holder of the Community authorisation is entitled to operate, *on a temporary basis* and without quantitative restrictions, national road haulage in another Member State without having a registered office or other establishment in that state.

Following their accession to the EU on 1 May 2004, restrictions have been lifted for hauliers from Cyprus, Malta and Slovenia as well. For other new EU member states, transition periods were in place with restriction periods mostly ending 1 May 2009.

The wording *on a temporary basis* in the Regulation 3118/93 turned out to be the reason for discussions as in practice it was not easy to demonstrate exactly when an activity ceases to be temporary and becomes permanent.

As a result of pressure from local hauliers, a number of the EU member states (Greece, UK, Italy and France) implemented restrictive measures to counter the cabotage liberalization. This was done in anticipation of the adoption of the new cabotage legislation.

Current Situation³⁵

Currently Regulation 1072/2009 is in force which limits the overall duration of the cabotage. It came into force on 14 May 2010. Article 8 of the Regulation limits the overall duration of cabotage to seven days and sets the maximum number of allowed cabotage operations to three. Before cabotage can start, the haulier must have entered the host Member State with a laden vehicle. This solves the interpretation problems that were in the Regulation 3118/93.

Currently a slight de-liberalization of cabotage has occurred. The new Regulation 1972/2009 has decreased the multilateral access to the cabotage market of the member states. This can lead to the same negative consequences that the regulation was initially set out to prevent. For example the increase in the quantity of the empty runs and the decrease of the competition levels in the road transport market could follow.

However, the European Parliament contrary to the position taken by the Commission and the Council has voted in favour of lifting all limits on cabotage by 2014.

Analysis

Initiation period

For this case the stimulus for the liberalization was the Treaty of Rome which allows supply of transport services by non-resident hauliers. This has led to gradual liberalization of cabotage. Without this stimulus, the liberalization of the road transport cabotage market could not have happened.

In this case the background has possibly played a role. The ECMT (currently ITF) has been a supporter of the construction of the European road transport market since the 70s. Outside the EU, the introduction of the ECMT permit system in 1973 was amongst the first steps towards liberalization of the international road transport market. It must be noted that EU member states are also members of the ECMT. In practice the introduction of this system for the non-EU member countries has led to the creation of a free access to international road transport market under the quota system. This has not led to liberalization of cabotage.

The introduction of the liberalization of road cabotage transport took much longer than expected. The initial plan was to introduce liberalization of cabotage by December 1969. It was initially supported by the European Commission, but after that, the Council blocked the implementation and the process halted.

It was not until the intervention from the European Court of Justice (Court of Justice ruling 22 May 1985) that the Council started acting and made a proposal that would permit cabotage.

In the initiation phase of this initiative, the stimulus is important for the initiation of the innovation process. However, an important decision maker has the ability to halt the process or postpone it for substantial periods of time. In this case, the Council has managed to postpone or slow down the initiation phase of the policy initiative.

Before the adoption of the 1993 regulation, there was extensive debate between the supporters of "consecutive cabotage" and supporters of "general cabotage". The compromise

³⁵ The wording "current" or "currently" in this thesis refers to the time of doing the research for the case or issue described.

was to not make the cabotage subject to prior international transport operation: adopting the general cabotage definition. However the compromise reached here would later in the implementation period of this policy innovation case prove to be an implementation barrier.

In general, the initiation phases of the EU legislative process involve a number of stakeholders, mostly on official grounds, to participate according to the legislative procedure of the EU.

Development period

The implementation of the liberalized cabotage system was preceded by a limited quota system. The quota system was a transition stage that served for both, adjusting the practical operation practices in the companies that would be willing to perform cabotage operations, but most importantly to show that the threat that the hauliers from the other member states represent is minimal. The initial introduction of the quota system was a smart move, as it allowed influencing the opinion of the market players.

As the initial quota system was a success and showed no loss of market share for the local companies, some countries were willing to proceed with even more liberalisation. Intra-Benelux cabotage was liberalized within two years from the introduction of cabotage. With the fears of the industry gone and the Commission reporting that cabotage quotas were largely underused, the quota system could be abolished, as there was no more opposition.

The gradual development of the cabotage system for several years seems to be the main reason for the success of this policy innovation. Due to the unclear results of this policy a kind of test within the limits of the quota system was needed. The quota system gave the stakeholders a sense of security and control of the process.

After the accession of the new EU member states from Eastern Europe, the situation had changed. The fears of losing the market share in the domestic markets to the hauliers from the East rose in the EU15. To protect the internal markets again, the Western countries used their political power to start the process of changing the rules of the game again and introduce cabotage limitations.

However, the legislative process in the EU is relatively slow. In anticipation of the adoption of the cabotage legislation, some member states unilaterally introduced rules similar to those of the new regulation (concerning limitation to three trips in seven days) in their legislations before the EU-wide introduction. This shows the influence the hauliers in the Western EU countries have at the local level.

There was pressure from the industry organizations to restrict the liberalization of cabotage. Some member states' positions were strongly influenced (ex. France) by industry organizations in their official positions.

In the development period of the cabotage system, there have been several barriers, but the main were the unwillingness of the EU member states (the Council) to start the legislative process and the failure of the legislators to agree on clear definitions in the text of the regulation.

The stimulus for this policy innovation has been weak, resulting in the long time needed for the legislation to get produced and adopted.

Implementation period

Pressure from the industry organizations at the implementation level has affected the way cabotage was liberalised. Transition periods and a limitation of the number of trips are examples of the results of such lobbying.

During the implementation period of the regulation, some countries took active countermeasures. For example, Greece, the UK, Italy and France implemented restrictive measures on cabotage. This happened in attempts to protect their internal market.

Different interpretations of the regulation in different countries were a barrier for the implementation and enforcement, which was due to lack of a clear definition of cabotage. As a result, new legislation had to follow. The failure to give clear definition in this case was a barrier for successful implementation of this policy innovation. The choice of gradual implementation ensured the success of cabotage liberalization.

Discussion

As described above, the legislative efforts have failed for a long time. The high barriers for the cabotage regulation throughout the legislative innovation process have been based on the distribution of power and economic reasoning.

In the Benelux countries, which were the first ones to liberalize cabotage in 1992, the road haulage cost structure was comparable. Therefore, fears of market disturbances due to cabotage liberalization were minimal. The minimal influence of cabotage liberalization on internal markets of the countries was proven in 1998 when the European Commission reported underuse of the cabotage quota. Similar cost levels allowed for efficient liberalization of the cabotage operations.

With the enlargement of the EU on 1 May 2004, the situation changed dramatically. Although the harmonization of the legislation of the new member states with the EU had happened, in practice, the hauliers in the new member states had lower costs. This was mostly due to labour and energy cost differences.

With the political power being in hands of the old EU member states, the ones with hauliers with higher costs, market protection was inevitable. The high influence of market actors on the positions of the member states in the Council results in protectionist decisions. It started with the maximum 5-year transition period introduced from the day of enlargement which had to end on 1 May 2009. It was reinforced by a number of EU member states (Greece, UK, Italy and France) implementing restrictive measures to counter liberalization. And from 14 May 2010, regulation 1072/2009 limits the duration and number of cabotage trips in the EU.

The effect of the cabotage market liberalization that the haulage industry could face in case of full liberalisation includes increased competition in the internal cabotage markets of the member states leading to lower haulage prices. This would result in lower profit margins of the road transport companies.

Initial conclusions

It can be concluded that in this initiation period of this EU level policy innovation a combination of the will to initiate from the Commission's side and the support of the EU

member states is crucial. The unwillingness of one of these stakeholders is a barrier high enough to stop or substantially postpone the policy innovation.

The influence of the member states wishing to keep the cabotage markets closed in the initial stages has been the highest barrier for this innovation case. Even when the cabotage regulation was in force, some member states that did not agree with the regulation were enforcing their own restrictions on cabotage to protect their local market.

Gradual, well-timed implementation of the cabotage regulation seems to have been the factor that ensured the success of this case, because political decisions that were made to come in force at a date far in the future seemed to face less opposition.

While analysing this case, a de-liberalization trend of the cabotage market with the adoption of the new Regulation 1972/2009 was observed. This shows the reversible character of the policy innovations with the possible negative effects, in this case the decrease of the cabotage market.

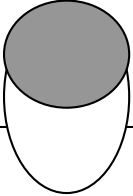
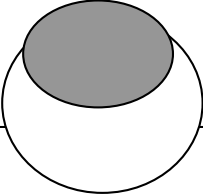
An interaction was observed between different international policy levels: the ECMT and the EU level. This policy innovation was influenced by the introduction of a three loaded trips limit in the ECMT multilateral road transport permit system. It was noticed that some countries are trying to transpose the condition of the "first loaded trip" to the conditions of use of ECMT multilateral quota.

6.1.1.2 Systems Innovation analysis

The SI analysis for the case study is described in section 3.3.1. The situation in the initiation, development and implementation phases is shown in the figures below.

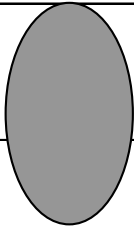
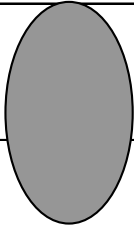
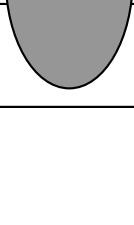
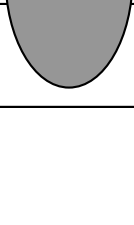


The mapped indication of activity (the shaded areas in Figure 29) in this phase indicates that the actions which needed to be taken and those which actually were taken in the process of innovation partially overlapped. This meant that all the conditions for success were established, but lack of covering some of the conditions in the *soft rules* section slowed down the process in the initiation phase substantially.

Figure 29: SI Overview of the EU Cabotage Case: Initiation Phase

Actors Institutional Environment	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
	Infrastructure conditions <i>Roads, Ports, Ships</i>			
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

In this phase, the mapped indication of activity (shaded areas in Figure 30) shows that activity, in comparison with the previous phase, has been extended to the *soft* rules in this phase of innovation. There were still *strong network problems* which action needed to be taken against in the process of innovation.

Figure 30: SI Overview of the EU Cabotage Case: Development Phase

Actors	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
	Institutional Environment			
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

The mapped indication of activity in this phase, shown in Figure 31, shows that it is in line with the actions which needed to be taken in the process of the innovation. This means that all the conditions for success were established.

Figure 31: SI Overview of the EU Cabotage Case: Implementation Phase

Actors				
	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
Institutional Environment				
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>	●		●	
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>	●			
<i>Strong network problems</i>	●		●	
Capabilities				

1. Detailed Analysis

The overview shown in the three diagrams provides only an indication of the areas where it appears that the innovator should have been operating to provide the correct policy stimuli. However, it is necessary to examine more closely what initiatives perhaps should have been taken. This will be done with reference to the SI structural categories.

1.1 Infrastructure Conditions.

This was not a specific factor in determining the presence of the success conditions for the EU international road transport market liberalization.

1.2 Institutional Conditions

1.2.1 Hard Rules. In a policy innovation case, this is clearly the area of activity where the key conditions for success of the cabotage liberalization proposal needed to be

established, because the aim of the innovation process itself was the production of *hard rules*.

1.2.2 *Soft Rules*. For this policy innovation the change of *soft rules* that are related to the political, economic, business, entrepreneurial, and cultural influences and values have played a role. First, the ECMT (currently ITF) has been a supporter of the construction of the European road transport market since the 70s. Outside the EU, the introduction of the ECMT permit system in 1973 was amongst the first steps towards liberalization of the international road transport market. Second, the liberalization of Intra-Benelux cabotage helped to deal with the fears of the industry. Last, but very important, the timing of the cabotage system introduction within several years was an important reason for the success of this policy innovation.

1.3 Interaction Conditions

1.3.1 *Weak Network Conditions*. Weak network conditions were noted in the implementation phase of the EU cabotage. The different interpretations of the regulation in different countries were a barrier for implementation and enforcement, which was due to a lack of a clear definition of cabotage.

1.3.2 *Strong Network Conditions*. Strong networks were the reason for slow implementation of the innovation and the form that it took when implemented. As noted in the previous analysis of this case, the pressure from the industry organizations at the implementation level has affected the way cabotage was liberalised. Transition periods and a limitation of the number of trips at the later stages are good examples of the results of such lobbying.

1.4 **Capabilities**. There appeared to be no lack of capabilities on the part of any of the actors.

2. Conclusions

2.1 Positive combinations

- In the initiation period of this EU level policy innovation, a combination of the will to initiate from the Commission's side and the support of the EU member states is crucial. The unwillingness of one of these stakeholders is a barrier high enough to stop or substantially postpone the policy innovation.
- For this innovation positive impacts of interactions in the area of *soft rules* were observed. The background of introduction of ECMT permit system and the liberalization of intra-Benelux cabotage has played a positive role for this innovation.
- The agreement of policy making actors on timing of introducing the cabotage regulation, which was stretched over several years, has played a positive role on the successful introduction of this policy innovation.

2.2 Negative combinations

- The influence of the member states wishing to keep the cabotage markets closed in the initial stages has been the highest barrier for this innovation case.

- Weak network conditions in the interactions between member states were noted in the implementation phase. The different interpretations of the regulation in different countries were a barrier for the implementation and enforcement.
- Negative impact in this innovation case arose also from strong networks – the pressure from the industry organizations has slowed the process down considerably – it has affected the way cabotage was liberalised.

2.3 Impact of policy intervention

- This innovation case is a policy innovation. In general, implementation of cabotage regulation was gradual and successful, with positive impacts for society. While analysing this case, a de-liberalization trend (in Regulation 1972/2009) was observed. This shows the reversible character of the policy innovations with possible negative effects: the decrease of the cabotage market.
- As a proof of existence of *strong network links*, an interaction between different international policy levels, the ECMT and the EU level, was observed. This policy innovation was influenced by the introduction of a three loaded trips limit in the ECMT multilateral road transport permit system. It was noticed that some countries are trying to transpose the condition of the "first loaded trip" to the conditions of use of ECMT multilateral quota.

2.4 Alternative proposed policy interventions

- The initiation phase of this EU level policy innovation was extremely long. This was due to the fact that a combination of the will to initiate from the Commission's side and the support of the EU member states was crucial. The unwillingness of one of these stakeholders was a barrier high enough to stop or substantially postpone the policy innovation. And the influence of the member states wishing to keep the cabotage markets closed in the initial stages has been high. In the initiation stage of this innovation, the *soft rules* had to be targeted from the Commission's side to promote and speed up the process.
- Throughout the entire innovation process, *strong network* problems were observed, especially in the development and implementation phases. Gradual, well-timed implementation was crucial to overcome these.
- Finally, the influence of both industry and third parties (lobbies etc.) has been strong throughout the innovation path. To maximize the success conditions, the focus in policy implementation cases like this should definitely be put on tackling the fears and countering the positions of these actors, because their influence can potentially make the innovation process fail.

6.1.2 Case 2 – Eurovignette directive

6.1.2.1 The case

Background and development

The aim of the Eurovignette directive is to lay down rules on how EU states may charge heavy good vehicles for using the road infrastructure. It aims at ensuring that road usage better reflects its true impact on society and the environment by introducing the “user pays” and “polluter pays” principles. Mode shift is also declared as one of the goals of the directive.

Historically, the realization of the importance of the vehicle taxation in the EU dates back to the 1960s when a large scale investigation took place of the various aspects of charging for the use of infrastructure. In 1968, the Commission made a proposal on a taxation system for commercial vehicles. In 1978, the Council agreed in principle to the draft Directive, but it was never adopted. In January 1988, a new proposal on the charging of road infrastructure costs for heavy goods vehicles was put forward and later adopted as Directive 93/89/EEC. This Directive was later annulled by the European Court of Justice on grounds of procedural irregularities.

In 1993 the European Commission (EC) presented a proposal for a directive enabling countries to introduce tolls on motorways in order to finance the cost of infrastructure deterioration caused by heavy goods vehicle traffic. But it was not until 1999 when Directive 1999/62/EC of the European Parliament (EP) and of the Council was signed and entered into force.

By 1 July 2000 the member states had to introduce laws, regulations and administrative provisions necessary to comply with this directive.

There were variations in the road charges and tolls on heavy commercial vehicles across Europe. The amounts that were charged and the methods that the systems used to calculate the charges differed substantially. The next version of the directive was proposed on 23 July 2003 to harmonize this situation and to extend the scope of the directive to more roads, vehicles and costs.

In the proposal of 2003 the possibility of tolling for some external costs was included (environmental damage, congestion and accidents). The possibility of financing alternative modes of transport, or so called cross-financing, to promote the freight modal shift away from road was included.

In reality, after the adoption of the directive in May 2006 it turned out to be a compromise. The member states agreed on levying charges on heavy goods transportation vehicles starting from 3.5 tonnes. This compared to the previous version of the directive included an addition of a substantial part of vehicles that the directive would apply to, compared to previous 12 tonnes. However the actual coming into force of the threshold was agreed to take place in 2012.

The main goal of the directive was to introduce the possibility for the EU member states to include “external costs” in their road transport pricing schemes. However, due to strong disagreements between member states and Parliament the final text excluded this possibility until a methodology for the calculation and internalization of external costs for all modes of

transport was agreed on. The EC promised to prepare a proposal for a calculation method two years after the directive comes into force.

On 8 July 2008, the EC published a proposal to revise the Eurovignette directive and offered a common calculation method to internalize external costs for all transport modes. Until 15 October 2010, when the Council reached political agreement on the draft directive on road use charges for heavy goods vehicles, the issue has been a source of disagreements and discussions. The opposing member states have been those at the periphery of the EU, like Portugal, Estonia and Malta, but also those who suffer most from the high transit volumes, like Austria, France and Germany.

During the discussions, several organizations and lobby groups expressed their opinions and tried to influence the legislative process.

The International Road Union's main criticism to the proposal was that the money raised is not fully reserved for the road transport sector and infrastructure improvements. The other criticism was that member states cannot compensate hauliers for the extra financial burden with reductions of other levies like vehicle tax and fuel duties. The International Tourism Alliance and the International Automobile Federation supported the IRU's position and announced that already the existing taxes easily cover the external costs of road usage.

A different opinion came from the Community of European Railways who saw this as a chance to reduce competition from the road sector. They called for even higher price levels, stating that it will not be possible to reflect all external costs in the current proposal.

The European Federation for Transport and the Environment said that the compromise reached still does not cover enough external costs that will still be on the shoulders of the EU citizens.

The International Association of Public Transport called for further extension of the infrastructure pricing policy to include private cars and urban areas. They said this would alleviate congestion and reduce environmental degradation. The reasons for statements like this seem obvious.

Current Situation

As described above, at the end of 2010, the Council reached political agreement on a draft of a new directive that will allow levying tolls that include the cost of air and noise pollution, as well as of congestion. This is a step forward in the direction of internalizing external costs for road transport.

Once the text, agreed upon by ministers in the Council, will be checked by the legal and linguistic experts, the Council will adopt its first-reading position on the draft directive and send it to the EP for a second reading.

The current proposal of the directive states that the revenues from road charges "should" be allocated to the transport sector to contribute to its sustainability. This wording is a result of compromise in the Council, but it will be a point of conflict with the EP. The latter is in favour of mandatory allocation of revenues from road charges to sustainable transport. The European Council is not itself unanimous on the question, because countries like Poland,

Bulgaria, Slovakia, Romania, Italy, Slovenia, Portugal and Estonia could support the principle of mandatory allocation.

Starting from 2012, the Eurovignette directive 2006/38 allows EU member states to levy charges on heavy goods transportation vehicles of more than 3.5 tonnes. This is a significant decrease from the 12 tonnes in the previous version of the directive.

Analysis

Initiation period

In the EU, the stimulus of innovation, according to the legislative procedure, has to come from the Commission. In this case, in 1993, the Commission was the initiator for a directive for enabling tolls on the motorways. The proposal came in order to replace Directive 93/89/EEC, which was annulled by the European Court of Justice on 5 July 1995 on grounds of procedural irregularities.

There are in fact two bodies that played a role in the situation which lead to the initiation process of this innovation. The official initiator was the EC, but it was only because of the previous annulment of the directive 93/89/EEC, that the Commission initiated the policy innovation. This policy innovation case reveals that the stimulus for such case may lie outside the initiator of the innovation.

Development period

A compromise of the EP, the EU Council of Ministers and the EC has been a prerequisite for the successful adoption of the legislation. This is defined in the legislative procedure of the EU, but it is also obvious that one of these three actors could halt the process as well.

In the development period of this policy innovation, there have been strong disagreements between member states of the EU and the EP. There are views that this has led to the lack of clarity in the legislation produced.

The adoption process of the three directives for this innovation case has faced serious lobbying from different sides, from different EU member states as well as from industry associations representing both road and competing modes of transport. Also, countries from outside of the EU, like Norway, have tried to influence the process. This shows the influence and importance of this policy innovation in the EU, but also outside.

The proposals of the initiation stage for the Eurovignette directive have faced opposition from the road transport sector, that stated that the measures proposed will not actually be efficient in reducing the external costs of road transport. The competition of the road transport industry, for example rail industry representatives, grasped their chance to use this as an opportunity for gaining a competitive edge in their business. The representatives of a public transport interest group tried to lobby to include passenger vehicles in the "vehicle" definition of this directive, for their business reasons.

The compromise that was reached at the Council in October 2010 for the latest draft directive on road use charges for heavy goods vehicles ("Eurovignette" directive) will be the reason for discussions between the EP and the Council. The Council agreed that the allocation of the revenues to the transport sector is not obligatory, but the EP's position is that there should be mandatory allocation of the revenues to sustainable transport. This position is also supported by several member states.

Implementation period

The transposition of the Eurovignette directive in the legislations of the member states is done when an appropriate law is adopted in a member state. Occasionally, laws already comply with the requirements of the directive, but in some cases additional legislative procedures in the member states are required.

The implementation of the Eurovignette directive in the road pricing schemes of different EU member states differs. Some have chosen to apply it fully, others have applied the directive only partially. The countries that have not applied the directive are in ongoing discussions about it.

The implementation of the Eurovignette directive has resulted in substantial changes in behaviour of the road transport operators. It seems to have mostly influenced the decisions of the companies on the renewal of their fleets of trucks – companies tend to buy cleaner trucks. This shows that some of the measures allowed in the legislation seem to have more effect than others.

Although the directive is developed with the best intentions, there are possible unwanted effects in the implementation period of Eurovignette directive. A negative phenomenon of detours is observed in the cases where pricing is applied only to the motorway network. There is also an incentive to reduce vehicle size in the fleet to fall below the cargo vehicle threshold of 3.5 tonnes (previously 12 tonnes) set by the directive. Therefore, a careful analysis of the impacts of the measures is important.

Discussion

The legislative process at the EU level takes considerable amounts of time, as it has taken for this policy innovation. This is characteristic because of the need to reach compromises, taking into account the opinions of all member states. The innovative process of the Eurovignette directive has an iterative character, with gradual changes in each iteration of the directive.

Another characteristic of the Eurovignette directive policy innovation has been the involvement of a large number of actors. The official EU institutions are only a part of the actors involved. Other actors, mostly from the road transport industry, have tried to influence the legislative outcome. An interesting observation was that the lobby of the competing modes of transport tried to influence the decision makers with the obvious aim of strengthening their competitive position.

The revenue redistribution seems to be the “hot issue” for the Eurovignette directive. The decision is not yet final. The road transport industry wants the revenues to be reinvested in valuable infrastructure. On the other side, most member states want to have free choice on the use of available funds. This is an area for a compromise to be reached.

Initial conclusions

In this EU level policy innovation case a combination of circumstances has led to the initiation of the process. The annulment of a previous directive was the spark to start the innovation process and produce a directive of improved quality. The actions of the European Court of Justice were important. Of course, at an EU level policy innovation, a combination

of the will to initiate from the Commission's side and the support of the EU member states is crucial, but a stimulus from another party was needed in this case.

In the development phase of the policy innovation, different stakeholders have shown a lot of interest and efforts to influence the decisions taken. The actors that played a role are not only the EC, EU member states and the EP, but also different interest groups and non-EU countries, which consider the impacts of the directive important to them.

The Eurovignette innovation case is currently undergoing a new development period, as a compromise was reached at the council in October 2010 for the latest draft directive.



The implementation of the Eurovignette directive has impacted the behaviour of road transport operators. The impacts have mostly been in line with the policy intended, but there are some unwanted impacts observed. The next iteration of the directive might solve this.

6.1.2.2 Systems Innovation analysis

Like for the previous case, SI analysis for the case study is done. The situation in the initiation, development and implementation phases is shown in the figures below.

The mapped indication of activity (the shaded area in Figure 32) in this phase indicate that the actions needed to be taken and those which actually were taken in the process of innovation partially overlapped. There was lack of covering some of the conditions in the *soft rules* section, which was not yet an issue at the initiation phase.

Figure 32: SI Overview of the Eurovignette directive Case: Initiation Phase

Actors				
	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
Institutional Environment				
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

In this phase, the mapped indication of activity (shaded areas in Figure 33) shows that activity had extended into the *soft* rules area in this phase of innovation. There had appeared to be *strong network problems*, which were targeted, but *capability problems* of the member states needed to be tackled.

Figure 33: SI Overview of the Eurovignette directive Case: Development Phase

Actors Institutional Environment	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

The mapped indication of activity in this phase, shown in Figure 34, indicates that it is in line with the actions which needed to be taken in the process of the innovation. This means that all the conditions for success were established.

Figure 34: SI Overview of the Eurovignette directive Case: Implementation Phase

Actors				
	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
Institutional Environment				
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

1. Detailed Analysis

The overview shown in the three diagrams above provides only an indication of the areas where it appears that the policy-maker (in this case the European Commission) should have been operating to provide the correct policy stimuli. However, it is necessary to examine more closely what initiatives perhaps should have been taken. This will be done with reference to the SI structural categories.

1.1 Infrastructure Conditions.

This was not a specific factor in determining the presence of the success conditions for the Eurovignette directive case.

1.2 Institutional Conditions

1.2.1 *Hard Rules*. In this policy innovation case this is clearly the area of activity where the key conditions for success of the Eurovignette directive proposal needed to be established, because the aim of the policy innovation is to produce policy measures. The hard rules were the stimulus for initiation: in this case, in 1993, the Commission was the initiator for a directive for enabling tolls on the motorways. The proposal came in order to replace Directive 93/89/EEC, which was annulled by the European Court of Justice on 5 July 1995 on grounds of procedural irregularities.

1.2.2 *Soft Rules*. For this policy innovation, the targeting of soft rules that are related to the political, economic, business, entrepreneurial, and cultural influences and values has been very important. This resulted in behaviour change of the road transport operators – in the decisions of the companies on the renewal of their fleets of trucks. Some soft rules were not tackled successfully, like the phenomenon of detours is observed in the cases where pricing is applied only to the motorway network. The trend of reducing vehicle size in the fleet to fall below the cargo vehicle threshold of 3.5 tonnes was tackled at a later iteration of this innovation.

1.3 Interaction Conditions

1.3.1 *Weak Network Conditions*. There were no *weak network* conditions noted that had influence on this innovation.

1.3.2 *Strong Network Conditions*. Strong networks were the reason for slow implementation and the form that it took when implemented. In the development phase of this policy innovation, there have been strong disagreements between member states of the EU and the EP. There are views that this has led to the lack of clarity in the legislation produced. Also, the adoption process of the three directives for this innovation case has faced serious lobbying from different sides, from different EU member states as well as from industry associations representing both road and competing modes of transport. Also, countries from outside of the EU, like Norway, have tried to influence the process. This shows the influence of strong network conditions that influenced this policy innovation.

1.4 **Capabilities**. In this policy innovation case, the implementing actors of the innovation are the member states of the EU. Occasionally, laws already comply with the requirements of the directive, but in some cases, additional legislative procedures in the member states were required.

2. Conclusions

2.1 Positive combinations

- In this policy innovation case *hard rules* are clearly the area of activity where the key conditions for success of the Eurovignette directive proposal needed to be established. The hard rules were the stimulus for initiation.
- For this policy innovation, targeting *soft rules* has had very positive impact for the successful development of the innovation.

2.2 Negative combinations

- There were no weak network conditions noted that had negative influence on this innovation.
- Strong networks were the reason for slow implementation and the form that it took when implemented. In the development phase of this innovation, there were strong disagreements between innovating actors (EU member states). Additionally, the process has faced serious lobbying from different actors.

2.3 Impact of policy intervention

- This is a policy innovation case. This policy resulted in behaviour change of the road transport operators – in the decisions of the companies on the renewal of their fleets of trucks. Some soft rules were not tackled successfully, like the phenomenon of detours is observed in the cases where pricing is applied only to the motorway network. The trend to reduce vehicle size in the fleet to fall below the cargo vehicle threshold of 3.5 tonnes was tackled at a later iteration of this innovation.

2.4 Alternative proposed policy interventions

- *Strong network conditions* have been the issue that the innovator had to tackle throughout the innovation process. Especially in the development phase of the policy innovation, different stakeholders have shown a lot of interest and efforts to influence or block the decisions taken. The actors that played a role are not only the EC, EU member states and the EP, but also different interest groups and non-EU countries, which consider the impacts of the directive important to them. It is concluded that efficient tackling of these conditions is important for the success of a policy innovation.
- A careful analysis of the impacts of the measures is important as the impact on the soft rules can be strong, but also unexpected. So, it was observed in the cases where pricing is applied only to the motorway network that unexpected traffic deviation occurred. Unexpected impacts could also be seen when companies reduced vehicle size in the fleet to fall below the cargo vehicle threshold of 3.5 tonnes (previously 12 tonnes) set by the directive.
- As already mentioned before, to maximise success conditions the focus should also be placed on the capabilities of the member states to implement the innovation.

6.1.3 Case 3 – Introduction of three loaded trips limit in ECMT multilateral road transport permit system

6.1.3.1 The case

Background and development

The ECMT multilateral quota system was initiated in 1970 by Resolution 22 of the Council of Ministers of the ECMT and was effectively implemented as of January 1, 1974 after the adoption of Resolution 26. Then it was seen by the Council of Ministers as a practical step towards gradual liberalization of road freight transport in conjunction with harmonization of terms of competition within the industry.

In practice, a new instrument for accessing the international road transport market was created – an authorisation which could be used for bilateral, transit and third-country trips between any of the ECMT³⁶ member countries.

The multilateral character of the licences served the purpose of rationalizing the use of permits by allowing better routing optimisation, thus reducing the number of empty runs.

The system saw a gradual development by promoting environmentally cleaner and quieter vehicles. The introduction of noise and emission standards for “green”, “greener and safer”, “EURO3 safe”, “EURO4 safe” and “EURO5 safe” lorries promoted the use of environmentally friendly and safe vehicles. Throughout the years, a system of coefficients and bonuses is used to determine the quota available to hauliers of a country based on how ecologically friendly the trucks are that use the licences. The quota available to hauliers is obtained by multiplying the number of licences a member country chooses in a specific category with the coefficient and bonus of the category. Table 29 shows the evolution of the basic quota conversion system in the recent years intended to promote the use of environmentally friendly vehicles.

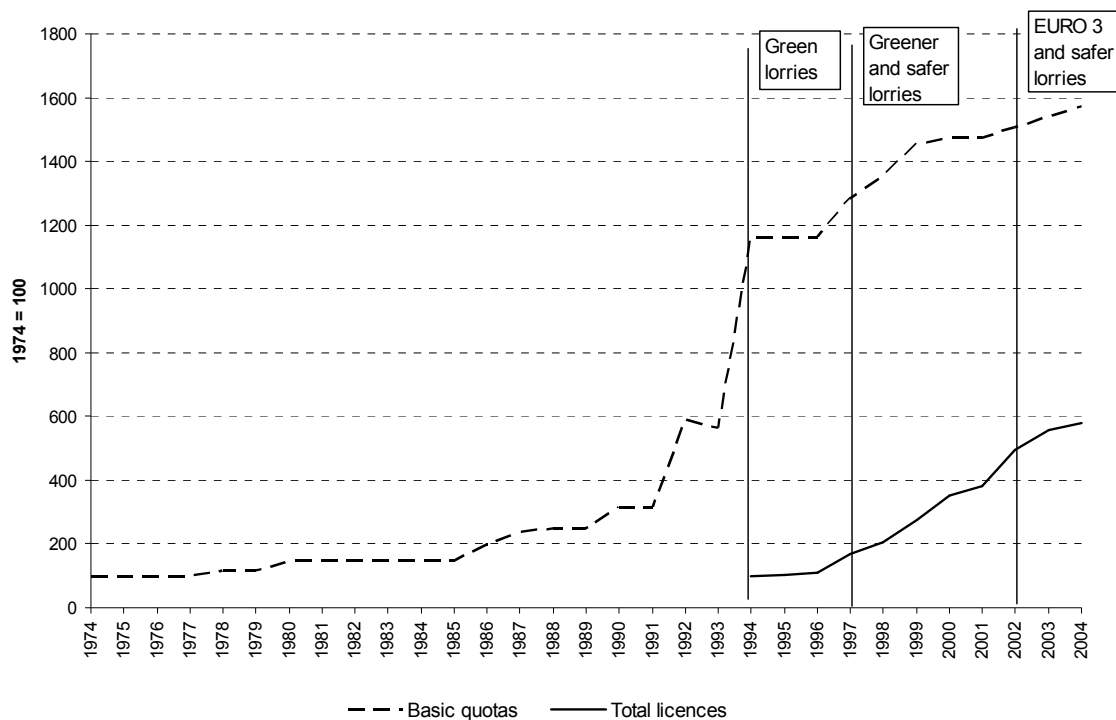
Table 29: Evolution of the ECMT system in recent years

	2007		2008		2009		2010	
	<i>Coeff Bonus</i>		<i>Coeff Bonus</i>		<i>Coeff Bonus</i>		<i>Coeff Bonus</i>	
EURO I	1		0					
EURO II	2		1		0			
EURO III	6	20%	6	10%	4	40%	4	20%
EURO IV	6	40%	6	40%	6	40%	4	20%
EURO V	6	40%	6	40%	6	40%	6	40%

Source: European Conference of Ministers of Transport (2006d)

The quota of the licence has been increasing gradually throughout the years as shown in Figure 35. The increase in quota followed the accession of new member countries and the will to facilitate the road transport operations.

³⁶ Currently the name of ECMT has changed to International Transport Forum (ITF), but the name of the permit system remains.

Figure 35: Evolution of ECMT quota from 1974 to 2004

Source: Fouvez (2005)

With the introduction of the Community licence system on 1 January 1993 in the European Union countries, the need for ECMT licences diminished. This was due to the obvious reason that the community licences covered a large part of the market that was previously only covered by the ECMT licence system and bilateral permit quotas.

On the other hand, the will to protect the bilateral international road transport markets of the member countries was strong. This was even more reinforced by differences in operation cost of road haulage companies in the Western European countries compared to the competitors from Eastern Europe.

The fact drawing attention of the industry to the matter of price differences was the so-called Willi Betz case, where the company relocated the official office for its operations to Eastern Europe and used the ECMT licences for operation within the EU. This case was discussed in the Committee of Deputies of ECMT.

In this situation, the Federal Office for Freight Transport of Germany carried out a survey during a four-week period from late February to late March 2002, copied all the logbooks and accompanying ECMT licences produced during roadside controls and carried out a statistical analysis of the records they contained. They concluded that “the ECMT multilateral quota is being used to a significant extent for purposes other than promoting economic links between EU countries and other European countries. Many ECMT licences issued to carriers from non-EU countries are used without any connection to home country trade flows”.

Following this analysis, the German delegation to the Group on Road Transport held in November 2002 proposed, that restrictions on the use of ECMT licences be introduced, whereby vehicles would be obliged to return to their country of registration with a certain frequency [European Conference of Ministers of Transport (2002a)].

The ECMT Secretariat received written comments from 26 countries to the documents drawn up by the German delegation [European Conference of Ministers of Transport (2002b)]. Oral comments during another meeting made in Sarajevo by several other Delegations should also be added. Altogether, 33 countries expressed themselves out of 41 participating in the system. It appeared at the meeting of the Group on Road transport held in November 2002, that the option of linking quota use to the number of journeys was not acceptable, therefore a proposal of time limitation of 8 weeks emerged. The vehicle would have to return to its country of registration after this time. Ministers of the member countries examined this proposal and agreed on a maximum period of 6 weeks, for implementation from 1 January 2004.

In practice, the time-based limitation turned out to act in a discriminatory way to the peripheral countries. Therefore a different kind of limitation was suggested.

Discussion on this issue showed sharply divided views. Some Countries wanted the restriction to allow for 8 or 9 trips, arguing that the analysis shows this number of trips corresponds to the 6 week restriction. Others wanted as few as two, arguing that there should be virtually no trips that are not bilateral. In June 2005 the Committee of Deputies, upon request of the Council of Ministers, agreed on a maximum number of trips of 3 journeys outside the country of registration, during which a haulier of a Member country is allowed to perform freight haulage within the ECMT territory with an ECMT licence, which means that after these trips, the haulier must come back to his country of registration. Empty runs outside the country of establishment are not taken into account since it is not considered a transport operation. A transport journey or empty run to, or in transit through, the state of establishment shall be considered a return. [European Conference of Ministers of Transport (2006e)]

Current Situation

This decision on a number of three trips was implemented from 1st January 2006 for a probationary period of one year and was prolonged. It is in force at the time of writing this document.

The future developments in this policy innovation case are depending on discussions about further development and restructuring of the whole ECMT permit quota system. The current distribution of the quota was approved by Ministers in 2006 [European Conference of Ministers of Transport (2006c), European Conference of Ministers of Transport (2006a)], for a minimum period of three years as from 1 January 2007. In order to prepare the new distribution of the quota, which was due for 2010, the Group on Road Transport started discussions in 2008; however the agreement is not yet reached.

At the time of writing, the ITF high level group suggests to ease the limitations, but Germany insists a ministerial decision has to be taken on this matter.

Currently, most of the ITF member countries stick to the perception that the limitations stay discriminatory and should be eased or abolished. Eastern European countries, Portugal and other countries with more dynamic economies are more prone to easing the restriction. Other countries fear that their hauliers will lose the competitive battle.

Analysis

Initiation period

In this innovation case, the triggers have been the developments in the road haulage market. The increasing market saturation with price pressures from the eastern-European hauliers was a reality. There was also the perception that the ECMT system was interfering with the international road haulage market in the EU. The Willi Betz case in particular was the one to be discussed in the meetings.

Germany was lobbying strongly in the initial stages of this policy innovation case. Initially, a statistically unreliable survey was used for this purpose. It also obtained support from other ECMT member countries with similar views for political support.

The member countries vividly reacted to the proposals of Germany. Most (33 of 41) expressed their views on the proposal.

There was a certain degree of uncertainty amongst the ECMT member countries about the effects of the initial 6-week restriction. They were unsure about the effects of the policy. Therefore, the initial restriction was introduced for a probationary period.

Development period

With the 6-week restriction already in place, but the system still relatively liberal, the will to restrict market access still remained.

During the development process of this innovation an important role was played by Germany. During the discussions in 2005, Germany teamed up with Switzerland, Spain, Belgium, Luxembourg and France (the 6 countries group). These countries have been "silently supporting" Germany's efforts throughout the innovation process of this case.

When a decision had to be taken on the actual number of trips that the limitation would set, the ECMT Ministerial Meeting decided to delegate the taking of this decision to the Committee of Deputies.

In the 2005 discussions, the disappointment of the peripheral countries because of the discrimination was taken into account by the 6 countries group, but only to be turned into even stricter proposals of market restrictions.

The discussions at the Committee of Deputies, which had to take the decision, were hard, as the views of the countries were sharply divided.

Implementation period

In the ECMT system, the implementation of the three-trip restriction was relatively smooth, although there were some interpretation and enforcement issues.

In the implementation period of this innovation, some countries transposed the rules set out by the ITF into their national legislations, although it was not obligatory.

The introduction of the three-trip cabotage restriction created misunderstandings in some countries (Greece, Austria and Italy), that the first trip for a haulier with ECMT licence should be loaded, as it is in the cabotage in the EU. This misconception, if true, would actually leave hauliers from import-oriented countries without the possibility to use the

ECMT licences at all. This would apply to most of the Eastern-European countries, where the economies are mostly import-oriented. However, this was only a misunderstanding because of almost analogous regulation for cabotage in the EU.

An interesting and rather unexpected development in the further spread of this policy innovation could be observed. After introduction of the three-trip limitation in the ECMT system, a similar three-trip limitation was promoted by Germany at the EU level and successfully introduced. Experts interviewed in relation to this case expressed the opinion that the three-trip limitation was used as a test ground by Germany for EU policy.

An interaction was observed between different international policy levels: the ECMT and the EU level. This policy innovation has influenced the policy at the EU level - the partial de-liberalization of the EU cabotage with regulation 1072/2009 which limits the overall duration of the cabotage to three trips. As feedback part in this loop, some countries are trying to transpose the condition of "first loaded trip" back to the conditions of use of ECMT multilateral quota.

Discussion

The introduction of the three loaded trips limit in ECMT multilateral road transport permit system has been based on the distribution of power amongst the member countries and economic reasoning.

The users of the ECMT permit system include countries with different legislative requirements, tax systems, energy costs and wage levels. All that influences the total cost that the haulier faces. The hauliers in the Western European countries tend to have higher cost levels than those of the other countries, including those outside the EU.

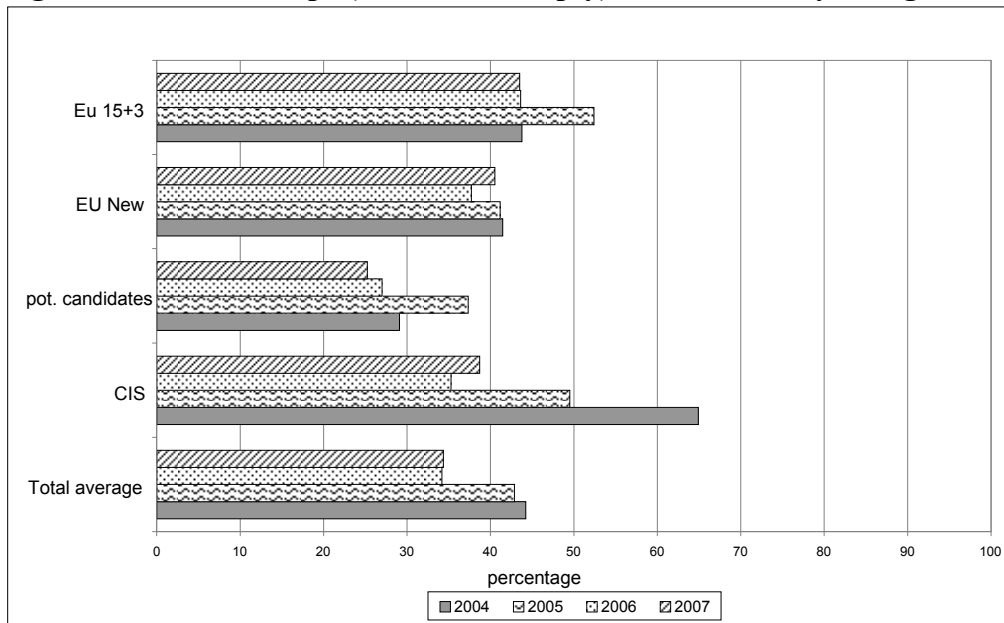
The ECMT permit system allows the participation of those hauliers with lower cost levels in the international road haulage operations, that would traditionally still be available for the Western European haulier. The difference in costs means that the hauliers with higher costs from Western Europe get priced out of the market.

As a result, the Western European countries actively try to protect the interests of their road haulage operators. The 6 countries group was formed for that purpose and included Germany, Switzerland, Spain, Belgium, Luxembourg and France. The high influence of these countries in the ECMT system guaranteed the success of the introduction of the three-trip restriction.

Figure 36 gives an insight on the impacts of the three-trip restriction on so called "third country traffic" in the period of 2004 to 2007 when the limitations came into force. The data include international loaded and empty trips. The total average of third country transport shows a significant decrease in 2006. The weighted average value for the two EU clusters shows a stable picture. In contrast, the share of third country transport with ECMT licences of operators registered in potential candidate countries decreased from 2005 to 2006 by about 10 percent points, whereas the share of trips made by CIS group operators outside their country of registration decreased considerably by 14 points to just 36% of all trips. Furthermore, the weighted average of the share of the third-country trips decreased within all regions between by 9 percentage points, from 43% in 2005 to 34% in 2006. The drop of this ratio in individual countries indicates that the three-trip restriction is discriminating the operators of countries which are located in the outer regions of the main ECMT area (e.g. from 2005 to 2006 for

Russia from 43% to 15% and for Albania from 89% to 69%), because of the difficulty of finding return load. [Meyer-Rühle and Dennisen (2009)]

Figure 36: Share of trips (loaded and empty) outside country of registration 2004 – 2007



Source: Meyer-Rühle and Dennisen (2009)

Initial conclusions

Coalitions of countries can play a major role in the situations where ranges of contradicting opinions exist. Like in this case, by creating a 6-country group, the objective was successfully achieved.

There are links between different road transportation related policy levels. In this case, there is the influence of the ECMT multilateral permit system restrictions on the EU cabotage regulation. And cabotage regulation in turn has influenced the ECMT restrictions.

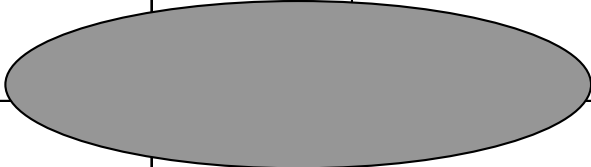


Despite the successful adoption of this policy, the influence of the measures on the market seems to be negative. It brings distortion to the international road haulage market favouring the countries in better geographical situation with balanced trade flows. It also encourages cheating by entering false data in the ECMT licence logbooks, therefore a substantial part of the ECMT member countries are against this policy.

6.1.3.2 Systems Innovation analysis

Like for the previous cases, SI analysis for the case study is done. The situation in the initiation, development and implementation phases is shown in the figures below.

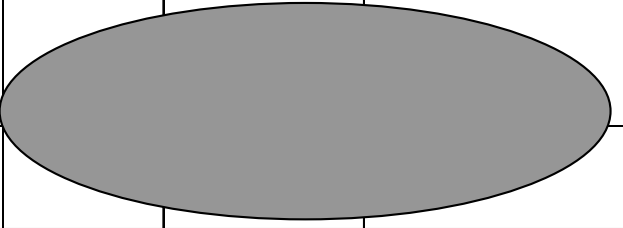
The mapped indication of activity (the shaded areas in Figure 37) in this phase indicate that the actions which needed to be taken and those which actually were taken in the process of innovation partially overlapped. This meant that most conditions for success were established, but lack of covering some of the conditions in the *weak network problems* section affected the initiation phase.

Figure 37: SI Overview of the introduction of three loaded trips limit in ECMT multilateral road transport permit system Case: Initiation Phase

Actors	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes RTD Funding. Standards Bodies
	Institutional Environment			
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

In this phase, the mapped indication of activity (shaded area in Figure 38) shows that activity has been extended to the *hard* rules in this phase of innovation.

Figure 38: SI Overview of the introduction of three loaded trips limit in ECMT multilateral road transport permit system: Development Phase

Actors Institutional Environment	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes RTD Funding. Standards Bodies
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

The mapped indication of activity in this phase, shown in Figure 39, indicates that a part of actions which could be taken in the process of the innovation to ensure its success were not taken.

Figure 39: SI Overview of the introduction of three loaded trips limit in ECMT multilateral road transport permit system: Implementation Phase

Actors	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes RTD Funding. Standards Bodies
	Institutional Environment			
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

1. Detailed Analysis

The overview shown in the three diagrams provides only an indication of the areas where it appears that the policy-maker (in this case the International Transport Forum) should have been operating to provide the correct policy stimuli. However, it is necessary to examine more closely what initiatives perhaps should have been taken. This will be done with reference to the SI structural categories.

1.1 Infrastructure Conditions.

This was not a specific factor in determining the presence of the success conditions for the introduction of the three loaded trips limit in the ECMT multilateral road transport permit system.

1.2 Institutional Conditions

- 1.2.1 *Hard Rules*. In a policy innovation case, this is clearly the area of activity where the key conditions for introduction of the trip limitation proposal needed to be established, because the aim of the innovation process itself was the production of *hard rules*.
- 1.2.2 *Soft Rules*. In this innovation case the soft rules had to be focussed on, because the trigger for innovation have been the developments in the road haulage market. The increasing market saturation with price pressures from the Eastern-European hauliers was a reality. There was also the perception that the ECMT system was interfering with the international road haulage market in the EU.

1.3 Interaction Conditions

- 1.3.1 *Weak Network Conditions*. The weak network conditions and the fact that those were not taken care of was possibly the reason for the failure of this innovation case. This was associated with the inability of the majority of the ITF member countries to form efficient opposition to Germany's proposal.
- 1.3.2 *Strong Network Conditions*. Strong networks were the reason for implementation of this policy innovation. During the development process of this innovation, an important role was played by Germany. During the discussions in 2005, Germany teamed up with Switzerland, Spain, Belgium, Luxembourg and France (the 6 countries group). These countries have been supporting Germany's efforts throughout the innovation process of this case.
- 1.4 **Capabilities**. There appeared to be lack of capability of ITF member countries on several dimensions. First, the impacts of this legislation were not clear: there was a certain degree of uncertainty amongst the member countries about the effects of the initial 6-week restriction. Therefore, the initial restriction was introduced for a probationary period. Also, it was not clear for countries how the implementation should be managed: some countries transposed the rules set out by the ITF into their national legislations, although it was not necessary. Last, there were enforcement issues: it created misunderstandings in some countries (Greece, Austria and Italy), that the first trip for a haulier with ECMT licence should be loaded, as it is in the cabotage in the EU. This misconception, if true, would actually leave hauliers from import-oriented countries without the possibility to use the ECMT licences at all. This would apply to most of the Eastern-European countries, where the economies are mostly import-oriented.

2. Conclusions

2.1 Positive combinations

- In this innovation case, the *soft rules* had to be focussed on, because the trigger for innovation have been the developments in the road haulage market. The increasing market saturation with price pressures from the Eastern-European hauliers was a reality. There was also the perception that the ECMT system was interfering with the international road haulage market in the EU. These interactions have been positive for the development of this policy innovation case.

- The *weak network conditions* and the fact that those were not taken care of was possibly the reason for the negative outcomes of this innovation case. This was associated with the inability of the majority of the ITF member countries to form efficient opposition to Germany's proposal. From an innovation process point of view, lack of agreement between those actors has benefited the process.
- *Strong networks* have also benefited this policy innovation. As described previously, Germany teamed up with Switzerland, Spain, Belgium, Luxembourg and France (the six countries group) to provide support for this policy throughout the innovation process of this case.

2.2 Negative combinations

- The level of negative interactions seems to be limited in this innovation case. The opposition was not strong enough to halt the innovation.

2.3 Impact of policy intervention

- This is a policy innovation. Despite the adoption of this policy, the influence of the measures on the market seems to be negative. It brings distortion to the international road haulage market favouring the countries in better geographical situation with balanced trade flows. It also encourages cheating by entering false data in the ECMT licence logbooks, therefore a substantial part of the ITF member countries are against this policy.

2.4 Alternative proposed policy interventions

- The capabilities of the actors of this innovative process (ITF member countries) to enforce the legislation were not taken into account. In practice there is no way of ensuring that the logbook records are correct. The policy should take these capabilities of enforcement into account to ensure successful implementation.

6.1.4 Case 4 – Variable speed limits

6.1.4.1 The case

Background and development

VSL systems are a type of Intelligent Transportation System (ITS) that utilizes traffic speed and volume detection, weather information, and road surface condition technology to determine appropriate speeds at which drivers should be travelling, given current roadway and traffic conditions.

These advisory or regulatory speeds are usually displayed on overhead or roadside variable message signs (VMS). VSL systems have been around for the last 30 years and currently are successfully being used and/or tested in parts of United States, Europe and Australia. VSL systems can be implemented in appropriate areas to help potentially reduce driver error and speeds, and to enhance the safety of our roadways through the use of innovative technology. [Robinson (2000)]

The first reported experiment of implementation of VSL was carried out in 1965 on a 30 km section of motorway A8 from Salzburg to Munich. The system consisted of mechanically variable message signs at a distance of 2 km, which could display speeds of 60, 80 and 100 km/h, and "danger zone" and "accident". Personnel monitored traffic using video technology, and manually controlled the signage. Zackor (1972) described the case reporting a decrease in traffic disruptions and breakdowns, harmonization of the velocity distribution and an increase in performance.

In the US, one of the first implementations of VSL was on a 5.2 km urban stretch of M-10 in Detroit (John C. Lodge Freeway) between the Edsel Ford Freeway (I-94) and the Davison Freeway. The speed signs could be manually switched at the control centre. It was dismantled after 1967, because Michigan officials felt variable speed displays did not significantly increase or decrease vehicle speeds.

In the late 1960s, VSL signs in combination with variable message signs were introduced in portions with high traffic volumes of the New Jersey Turnpike. The purpose of the system was to provide early warning to motorists. The speed limit is displayed automatically on 120 signs over 148 miles according to weather, traffic conditions, and construction. Other implementations in the US are typically related to road sections with possible dramatic changes in driving conditions. [Robinson (2000)]

Figure 40: One of the signs of the New Jersey Turnpike



Source: Schumin (2011)

In the UK, a VSL system was introduced on part of motorway M25 in its busiest 23km section from junction 10 to 16. According to a report of the National Audit Office (2004), the initial results of the one year trial of Variable Speed Limits indicated savings in journey times, smoother flowing traffic and a fall in the number of accidents. On the basis of these findings, The Highways Agency converted the trial into a permanent facility in 1997. However, the same report noted that the business case was unproven; conditions at the site of the VSL trial were not stable before or during the trial, and the study was deemed neither properly controlled nor reliable. As a result, in 2002 the VSL trial was continued at a further budgeted cost of £3.9 million to cover an additional eight kilometres of the M25 where conditions were expected to be more stable in order to collect sufficient before and after data to prepare a business case.

Another VSL system near London on the M1 was made permanent starting from January 2010. [BBC News (2010)]

In New Zealand in February 2001 Transit New Zealand (TNZ) commissioned the operation of the Ngauranga Active Traffic Management System (NATMS) on State Highway 1, north of Wellington, New Zealand. The NATMS covers a 4km stretch of State Highway between Johnsonville and the SH1 / SH2 Interchange. The NATMS is the first system in New Zealand to use Automatic Incident Detection and was chosen because of the challenging driving conditions which are compounded by steep terrain, numerous bends and a high degree of weaving between lanes. An important feature of NATMS is that it is designed for incident detection and is not a traffic management tool intended to increase efficiency and travel time. [Fergus and Turner (2002)]

In Austria, an experiment of introducing a VSL system was conducted in 2006. During a month of June, a stretch of motorway was equipped with a VSL system which could increase the maximum speed up to 160 km/h (from general speed limit of 130 km/h). The experiment was discontinued. [ORF (2006)]

Trials with VSL for different applications were carried out by the Swedish Road Administration in 2003 - 2008. The goal has been to demonstrate if and how VSL can contribute to a better speed adaptation in a cost-efficient way. The VSLs in Sweden are applied as traffic controlled and/or weather controlled. The speed limit is temporarily adjusted downwards on major roads when certain conditions are met. The implementation includes 20 objects in total. Six out of these are traffic controlled. [TEMPO Evaluation Expert Group (2009a), TEMPO Evaluation Expert Group (2009b)]

Figure 41: Traffic controlled VSL in Norrtäljevägen E18



Source: TEMPO Evaluation Expert Group (2009b)

In Belgium, a VSL system on the beltway around Antwerp (Belgium) was introduced in 2003. The introduction was linked to major road works. The system also includes a part of a radial highway towards this beltway (E313 motorway). The VSL system applies a control algorithm that uses speed and density measurements from camera detectors. The primary

function is warning drivers for downstream congestion. The regular speed limit in the network is 100 and 120 km/h on the beltway and E313 respectively. The VSL algorithm can impose two reduced speed limits, 50 and 70 km/h, with higher speeds (70, 90 or 100 km/h) displayed on the upstream gantries to guarantee a gradual speed reduction. The VSL are not enforced and from the detected speeds, it is clear that compliance is poor. [Corthout *et al.* (2010), Deknudt and Dechamps (2011)]

Figure 42: VSL signs near Antwerp



Source: Anon.(2008)

Current Situation

Various implementations of the VSL systems have taken place in various places around the world. Since the beginning of the 1970s, the implemented systems have moved away from manual switching of the signs. Modern systems include a control centre that uses either AID system or rely on person-operated speed adjustments.

Different approaches are taken in creating the system. The triggers for speed limit adjustments differ, and usually include weather and traffic-related conditions.

The wide spread of the innovations allows placing it in the maturity phase with a range of available implementations around the world.

In the future, the developments in the VSL systems are expected to be more subtle. They may include optimization of reaction speeds, improvements of algorithms and short-term prediction models.

Analysis

The innovation path of one of the previously mentioned VSL system implementation cases – on the beltway around Antwerp (Belgium) is analysed in detail.

Initiation period

A trigger for the introduction of a VSL system in the case of Antwerp came in the late 1990s from a study that was commissioned to a consultancy on the possibility of implementing a VSL system in the Flemish region of Belgium. The study confirmed the expected positive effects of implementation of the system and set out guidelines for implementation. The implementation of the system has followed the guidelines set out at that time.

From the organizational point of view, a special unit was created in Verkeerscentrum Vlaanderen in order to focus on traffic management issues. Initially, the focus of the unit was on the Antwerp region. Only later, with the expansion of the scope of the project, the working area would expand to Flanders as it is now.

In the initiation stages of the VSL innovation, a strong support came from the political level of the Flanders region, because in Belgium road works are the competency of regions. With the support of the minister for the introduction of VSL, as an initial stage, an incident detection system and variable message signs were put in place.

A logical step in Belgium would have been to start with the introduction of a VSL system on the Brussels ring road. However, the fact that the Brussels ring road crosses territory of all three regions of Belgium, and that road works are the responsibility of the regions themselves has been a barrier high enough for the implementation to fail at the initiation phase on the Brussels beltway. This allowed for the VSL system to be first implemented on the Antwerp beltway. The work on the introduction on the Brussels beltway road has not yet started at the time of finalizing this thesis.

Development period

A positive effect on the development of the system was played by an EU CENTRICO project on cross border traffic management in 1999. Within CENTRICO, several cross border corridors have been defined for international traffic management such as corridor rerouting, and incident management to face recurring congestion and traffic disturbances. These measures were implemented using ITS, and progress is supervised by the Steering Committee and working groups. [De Haan (2006)]

The push for this innovation were the major road works scheduled to be done on the Antwerp beltway. The innovation itself was developed around these major road works.

There was no direct influence from the professional organizations or interest groups. The opinion that they created in the press was that something in the area of traffic optimization had to be done. For the implementation of the VSL system in Antwerp, this was favourable.

There was no clear funding policy. In the initial years of the project, annual budgets were available. Once the budget was assigned, there were no barriers to building the system.

The barriers were low or non-existent, because the VSL system was implemented as one of the measures at the time of road works.

Implementation period

All the choices on the specific aspects of the VSL system were left to the Verkeerscentrum Vlaanderen. No influences from the political level or lobby groups were present.

Implementation of the VSL system was linked with organizational changes and increase of unit size. Also, some of the tasks were passed on to automation, as it turned out too much to handle for the available workforce.

A reform of the administration in 2006 lead to splitting the investment and building activities from operating the VSL system. This can make future system developments more difficult.

The financing for the implementation phase of the VSL system was closely linked to major road works on the ring road. The VSL system was only a part of a set of measures taken.

In 2003, when the VSL (or delay control system) was launched, the road users had little or no expectations, because the implementation was linked to other major changes in the road network.

No changes in the legal regulation were required to implement and operate the VSL system.

To a certain degree, knowledge transfer from the countries with more experience and cooperation to other traffic related projects has facilitated the introduction of this innovation.

Discussion

Decisions on the introduction of VSL systems are usually made at the policy level. Once the funding is granted for this innovation, there are obviously less barriers for the introduction of this innovation.

This innovation is interesting, as it shows how the barriers to implementation can change over time through different stages of the innovation.

Performing a cost-benefit analysis for the introduction of VSL systems can be difficult. The problem is usually the unavailability of comparable data, or bad quality of the latter. For example, in the implementation of the M25 in the UK, according to a report of National Audit Office (2004), the data available was of poor quality and therefore the results were unreliable. In other places, like the Antwerp ring road, there are no data available at all before the implementation of the system, because the traffic detectors are installed as a part of the VSL system at the same time.

The success or failure in each implementation can vary, and the factors that can influence it can be either technological or cultural. Technological factors are linked to how the implementation is executed, where it is implemented, what are the triggers for a speed limit to change, what kind of change (increase or decrease) of speed limits is done, and what are the enforcement procedures in place, if at all. From the cultural side, a big role is played by the perception of public, politicians and authorities. The failure of this innovation can be triggered by the perceived inefficiency of the measures.

A good example of failure of VSL implementation because of administrative barriers in the initiation stage of the innovation is the Brussels ring road. But failures are possible even after the implementation was done, like in Michigan, US (Robinson (2000), p.8) because of low impacts, or possibly too high expectations, or lack of enforcement.

Initial conclusions

The reasons for introducing the same innovation, VSL system, can differ from application to the application. The evaluation of the innovation case should therefore also be linked to the goals set beforehand.

Although the VMS systems are implemented in various locations, one of the often reported problems is the poor compliance of the drivers to the speed limit being enforced. In some cases, for example in Michigan, US (Robinson (2000), p.8), this was the reason for the system being dismantled after some time.

Another unsuccessful application of the system in Austria³⁷, was terminated for the reason that it was designed to increase the maximum speed limit in favourable road conditions. There was strong resistance from the opposition politicians and green action groups.

The evaluation of the systems is often difficult, as there is no comparable data for cost-benefit analysis. For example, in the Antwerp implementation, the traffic detectors were installed at the same time the variable message signs were installed.

The implementation of a VSL system can lead to organizational expansion or changes, which is linked with the specific knowledge/skills required for the operation of the system.

In the initiation stage, the political decision makers play a crucial role, but at later stages their importance/impact diminishes. They can also halt the process in the initiation stage, like in the example of failed implementation on the Brussels ring road mentioned above.


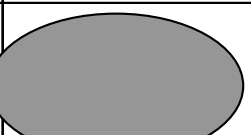


³⁷ ORF (2006)

6.1.4.2 Systems Innovation analysis

Like for the previous cases, SI analysis for the case study is done. The situation in the initiation, development and implementation phases is shown in the figures below.

The mapped indication of activity (the shaded areas in Figure 43) in this phase shows the actions which were taken in the process of innovation. Some conditions for success were covered, but lack of covering other conditions in the *strong network problems* section affected the initiation phase.

Figure 43: SI Overview of the Variable Speed Limits Case: Initiation Phase

Actors Institutional Environment	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

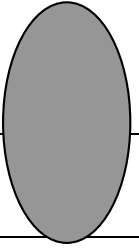

In this phase, the mapped indication of activity (shaded areas in Figure 44) shows that activity has been extended through several institutional environments in this phase of innovation.

Figure 44: SI Overview of the Variable Speed Limits Case: Development Phase

Actors Institutional Environment	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
	Infrastructure conditions <i>Roads, Ports, Ships</i>			
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

The mapped indication of activity in this phase, shown in Figure 45, shows the actions were targeted at the institutional conditions and to increase the capabilities of the innovator.

Figure 45: SI Overview of the Variable Speed Limits Case: Implementation Phase

Actors Institutional Environment	Road Sector	Shippers/ Forwarders	Third parties Lobbyists; Consultants; Manufacturers	Knowledge Institutes EU RTD Funding. Standards Bodies
	Infrastructure conditions <i>Roads, Ports, Ships</i>			
Institutional conditions Hard Rules: <i>Laws, regulations</i>				
Soft Rules: <i>social and economic values</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

1. Detailed Analysis

The overview shown in the three diagrams provides only an indication of the areas where it appears that the innovative actor (in this case the Flemish Government) should have been operating to provide the correct policy stimuli. However, it is necessary to examine more closely what initiatives perhaps should have been taken. This will be done with reference to the SI structural categories.

1.1 Infrastructure Conditions.

This was not a specific factor in determining the presence of the success conditions for the introduction of Variable Speed Limits on the Antwerp ring road. But it must be mentioned that this innovation itself was enabled by and developed around major road works on Antwerp ring road.

1.2 Institutional Conditions

- 1.2.1 *Hard Rules.* No action in the area of hard rules was required: no changes in the legal regulation were needed to implement and operate the VSL system. Also, there was no clear funding policy. In the initial years of the project, annual budgets were available. Once the budget was assigned, there were no barriers to building the system.
- 1.2.2 *Soft Rules.* There was strong action in the soft rules area, especially in the initiation stages of the VSL innovation. It came from the political level of Flanders region, because in Belgium road works are the competency of regions. With the support of the Minister for the introduction of VSL, as an initial stage, an incident detection system and variable message signs were put in place.

1.3 Interaction Conditions

- 1.3.1 *Weak Network Conditions.* The interaction conditions became weaker with the reform of the administration in 2006, which led to splitting the investment and building activities from operating the VSL system. This made future system developments more difficult.
- 1.3.2 *Strong Network Conditions* have been a barrier for the implementation of the VSL system in a place where it was needed most. A logical step in Belgium would have been to start with the introduction of a VSL system on the Brussels ring road. However, the fact that the Brussels ring road crosses territory of all three regions of Belgium, and that road works are the responsibility of the regions themselves has been a barrier high enough for the implementation to fail at the initiation phase on the Brussels beltway.
- 1.4 **Capabilities.** There appeared to be no lack of capabilities on the part of any of the actors. All the choices on the specific aspects of the VSL system were left to the Verkeerscentrum Vlaanderen. No influences from political level or lobby groups were present. Also, the implementation of the VSL system was linked with organizational changes and increase of the unit size, as it turned out more workforce was required.

2. Conclusions

2.1 Positive combinations

- The timing of the implementation of this innovation played a role in determining the presence of the success conditions for the introduction of Variable Speed Limits on the Antwerp ring road. Because it was enabled by and developed around major road works on Antwerp ring road.
- No action on policy change was required for the implementation of a VSL system.
- Available funding has played an important role for success. In the initial years of the project, annual budgets were available. Once the budget was assigned, there were no barriers to building and operating the system.
- There was strong action in the soft rules area, especially in the initiation stages of the VSL innovation. It came from the political level of the Flemish region with the support of the Minister.

2.2 Negative combinations

- Structural changes in the Flemish administration have potentially impacted negatively the development of the VSL system by splitting the investment and building activities from operating.
- As described above, strong network conditions have been a barrier for the implementation of the VSL system in a place where support was needed most - on the Brussels ring road. The fact that the Brussels ring road crosses territory of all three regions of Belgium, and that road works are the responsibility of the regions themselves has been a barrier high enough for the implementation to fail at the initiation phase on the Brussels ring road.

2.3 Impact of policy intervention

- The impacts of policy level on this innovation have been important only at the initiation phase when it was decided about the funding. At the later stages no impacts were noted.

2.4 Alternative proposed policy interventions

- The focus in this innovation case was partially placed on knowledge transfer from the countries with more experience and co-operation to other traffic-related projects. It has facilitated the introduction of this innovation and ensured optimum success conditions. Therefore, stimulating knowledge transfers is advisable.
- Strong network conditions with high responsibility levels of regions can be a high barrier in the areas where the interests meet. To ensure the success in such cases, high importance should be placed on political agreement between these actors to ensure the success of the project.
- This innovation case shows that it is important to target *soft rules* in the initiation stage, because the political decision makers play a crucial role then. At later stages, their importance/impact diminishes. They can also halt the process in the initiation stage, like in the example of failed implementation on the Brussels ring road mentioned above. When decisions on the introduction of VSL systems are made at the policy level and the funding is granted, there are obviously less barriers for the introduction and a higher chance of success.

6.2 Other case studies used

Within the InnoSuTra project, Arduino *et al.* (2011b), the same methodology is used for investigating cases in other domains of the surface transportation. There were 23 cases investigated in total. 9 cases can be considered “successful”, 8 are “failure or not-yet-successful” and the other 6 are “intermediate”. The cases investigated in this research and within the project are shown in Table 30 and Table 31.

Table 30: Success cases analysed

	Road	Rail	Maritime	IWW	Intermodal
Technological	ITS: Variable Speed Limits (VSL)*		Reefer containerisation	Information Technology in the inland navigation industry	Port Community System (PCS)
					Superfast Ferries (SFF)
Organizational		Eurotunnel			Freight Villages (FV)
Policy	EU Cabotage*		Port State Control (PSC)		

*investigated in this research.

Source: Arduino *et al.* (2011a)

Table 31: Not-yet-success cases analysed

	Road	Rail	Maritime	IWW	Intermodal
Technological			Cold ironing	Air lubrication of ships	
Organizational			Indented berth	Available capacity on small IWW	
Policy	Eurovignette Directive*				Internalization of external costs
	ECMT three trips limit*				European Intermodal Loading Unit

*investigated in this research.

Source: Arduino *et al.* (2011a)

The conclusions from all the cases are used in the next subchapter for the application of SI analysis to the case study investigated in this research. The interactions mapping within the SI matrixes of these cases is summarised to be applied to the case study of introduction of road pricing on the Belgian road network. This allows determining the areas where the actions taken would ensure successful introduction of the innovation.

6.3 Application of the Systems Innovation analysis to the case of road pricing

6.3.1 SI analysis

The application of the SI analysis is done for the selected case: the Scenario 4 from the impacts simulation section 4.2 (described in subchapter 5.1). It models a realistic situation where a road pricing scenario is introduced on the road network.

1. Introduction

The case investigated deals with the possible adoption of a road pricing scenario on the Belgian road network for the heavy goods vehicles. The case does not deal with the development of the technology of the road pricing itself, but rather the innovation path of the

related policy making process, which should enable the development of the road pricing system for the road transport network.

The case addresses the need to make the appropriate decisions from the innovators side. In this case the innovator is the government. The actions would include making appropriate decisions, assigning financing, subcontracting and other tasks for the road pricing system to be introduced.

According to the methodology, the case of introduction of pricing on Belgian road network is currently in the beginning of the initiation stage. The typology of stages of the innovation process is described in chapter 2.1.3.

According to the typology of innovations (described in chapter 2.1.2), the case falls into the category of “Managerial, Organisational, Cultural – Market (Policy Initiatives)” innovations, because of the high level of political involvement that this innovation requires. For the cases in this category specific areas that need to be targeted for the success of the innovation have been identified³⁸. Those are shown below in Figure 46, Figure 47 and Figure 48.

The application of SI analysis is done to assess the current situation in the development of the case and propose areas for actions during the different stages of development that could ensure success of the innovation. The suggestions are based on other previously analysed cases that fall in the same category of “Managerial, Organisational, Cultural – Market (Policy Initiatives)”.

Figure 5 on page 16 shows the possible adoption paths that an innovation can follow. This innovation follows a welfare path, where certain favourable institutional factors and funding mechanisms have to be created for successful market uptake.

2. Current State of Development

The introduction of road pricing mechanisms in the member states of the European Union is enabled by the legal framework of the Eurovignette directive. It aims at harmonizing the road charges and tolls for heavy commercial vehicles across Europe. It sets limits for the amounts that are charged and for the methods that are used to calculate the charges.

Belgium, together with Denmark, Luxemburg, the Netherlands and Sweden were members of sticker or vignette system that the users of this scheme had to attach to the windcreens of their vehicles. However, since the beginning of 2008 the Eurovignette is an electronic system and physical vignettes are no longer printed. Also, the UK³⁹ is considering the introduction of a vignette system. Other neighbouring countries have used the framework of Eurovignette directive to construct different road pricing systems for heavy goods vehicles. France is collecting tolls only on the main motorways using toll collection points. Germany, Czech republic, Austria and Switzerland are using integrated electronic network-wide collection systems, where electronic vehicle tracking systems are used to determine the toll to be paid.

In recent years, following the example of the latter group of countries, the introduction of road pricing has been discussed in Belgium at federal level⁴⁰. The possibility of linking the

³⁸ Arduino *et al.* (2011b)

³⁹ Handy Shipping Guide (2012)

⁴⁰ GVA (2009)

cancellation of the tax on first registration and yearly circulation tax with introduction of road pricing is also discussed. On the regional political levels similar discussions have taken place. In general, the topic is considered controversial.

The example of the planned road pricing introduction in The Netherlands seems to have served as a stimulus for the development of the idea in Belgium. The Dutch scheme was planned to be a GPS-based one with varied pricing levels according to the time of day and place of the road network. It would mean equipping all the vehicles with an onboard unit. The introduction of this scheme in the Netherlands was cancelled because of government change.

An agreement to introduce road pricing for heavy goods vehicles by 2013 was reached by the Belgian communities in January 2011.⁴¹ Currently the agreement concerns only heavy goods vehicles of more than 3.5 tons, and the expansion of the system to all vehicles does not seem likely in the short term.

The opposition parties, however, fear that the introduction of the road pricing at a stage where the Netherlands have cancelled the plan to do it could put the Belgian logistics sector in an unfavourable position. Therefore, in 2011 Belgian politicians called on the new Dutch government to re-evaluate the decision to stop with the project, because it was planned that Belgium and the Netherlands would both introduce road pricing.

Another opposition argument from VAB (Vlaamse Automobilisten Bond), which represents the interests of road users, states that this is a measure to fill the budget at the expense of road users and that in this case the environment is an excuse for extra taxation.⁴²

Also, the support by the public for the introduction of road pricing in Belgium is low. A poll⁴³ of car users at a car expo in Brussels showed very low support of the public for any kind of pricing measures, which shows the lack of work done in the area of creating public opinion.

On the other hand, UNIZO, the organization of entrepreneurs, supports the introduction of road pricing and states that it should be done together for all Benelux countries. That should ensure uniform tariffs and lower overhead costs of the system.⁴⁴

There have been different studies on the impact of road pricing, optimal toll levels and there is even a test project⁴⁵, where the behaviour of several inhabitants of Leuven under pricing conditions is observed.

The experience gained from the other cases investigated in this research allows identifying some areas where the barriers for the success of introduction of road pricing for heavy goods vehicles in Belgium could arise.

⁴¹ HLN (2011b)

⁴² HLN (2012b)

⁴³ HLN (2012a)

⁴⁴ UNIZO (2009)

⁴⁵ HLN (2011a)

SI Overview of the Introduction of pricing on road network case: Initiation Phase

The shaded cells in the initiation phase, in Figure 46, show where actions should be taken in general for the “Managerial, Organisational, Cultural – Market (Policy Initiatives)” type of innovations. The darker the cells are, the more important this area is for this type of innovation. Taking into account the specifics of the case, the ovals show the suggested areas of attention for this specific case. The ovals with line pattern show the areas where actions were already noticed during the research.

Figure 46: Initiation phase

	Knowledge Institute	Public Funding	Private Funding	Standard Bodies	Initiator/ Entrepreneur	Developer/ Industry	Transport Operators	Lobbyists
Infrastructure <i>Ports, etc.</i>								
Institutional <i>Hard: Laws, regulations</i>								
Institutional <i>Soft: norms, values</i>								
Interaction <i>Weak network</i>								
Interaction <i>Strong network</i>								
Capabilities								

3. Proposed Policy Interventions and Actions

SI Overview of the Introduction of pricing on road network case: Development Phase

The innovation case has not yet reached the development phase, but for future reference, based on the evidence of other cases, some areas of attention can be suggested. The shaded cells in Figure 47 show the areas that should get attention during the development phase. The most important are shaded darker.

Figure 47: Development phase

	Knowledge Institute	Public Funding	Private Funding	Standard Bodies	Initiator/ Entrepreneur	Developer/ Industry	Transport Operators	Lobbyists
Infrastructure <i>Ports, etc.</i>								
Institutional <i>Hard: Laws, regulations</i>								
Institutional <i>Soft: norms, values</i>								
Interaction <i>Weak network</i>								
Interaction <i>Strong network</i>								
Capabilities								

SI Overview of the Introduction of pricing on road network case: Implementation Phase

The case of introduction of pricing on road network is still far from the implementation phase, but based on cases investigated previously, the areas of attention can be outlined. The most important are shaded darker.

Figure 48: Implementation phase

	Knowledge Institute	Public Funding	Private Funding	Standard Bodies	Initiator/ Entrepreneur	Developer/ Industry	Transport Operators	Lobbyists
Infrastructure <i>Ports, etc.</i>								
Institutional <i>Hard: Laws, regulations</i>								
Institutional <i>Soft: norms, values</i>								
Interaction <i>Weak network</i>								
Interaction <i>Strong network</i>								
Capabilities								

Proposed interventions in detail

The overview shown in the diagrams above provides only an indication of the areas where it appears that the policy-maker (in this case the Belgian federal government) should provide the correct stimuli. However, it is necessary to examine more closely what initiatives perhaps should be taken. This is done with reference to the SI structural categories.

3.1 Infrastructure Conditions

In the initiation stage that the innovation case is currently undergoing actions targeting infrastructure conditions are not required. However, it can be seen that some initial actions are already taken, like a test project in Leuven⁴⁶. At the current stage of innovation the presence of certain infrastructure conditions is not required for a successful outcome of the innovation process. At later stages of the innovation process, specifically in the implementation phase, the creation of appropriate infrastructure for the operation of the road pricing system is important and should receive sufficient attention.

3.2 Institutional Conditions

Hard rules. The development of this case includes policy, technological and cultural components. In the hard rules area of activity the policy component is the one that plays the key role for success. In similar cases, historically, the innovation process has been policy-driven. As can be seen from the figures above (see Figure 46, Figure 47 and Figure 48), the actions throughout all three stages of the innovation process should cover a range of actors (standardizing bodies, entrepreneurs, developers/industry, transport operators and lobbyists). From what can be seen currently (in Figure 46 in row “Institutional Hard”), at the current initiation stage of the innovation, not enough steps have been taken by the government in this area. For the current stage of innovation to finish, appropriate steps in those “blank” areas would be beneficial.

In the development stage, the interaction should involve standardizing bodies, to ensure the interoperability requirements of the system developed. Also, at this stage the timing of the created legislation is important. It should be passed well in advance. This will allow the road operators and their clients to be well informed and make informed business decisions. Also, a change that is further away in the future is easier to accept. In addition to those aspects, in the

⁴⁶ HLN (2011a)

implementation stage, an efficient involvement of an industrial partner, in this case the company or consortium that builds and creates the system becomes important.

Soft Rules. The experience from other analysed cases shows that soft rules are of lesser importance during the initiation and development phases, but it is very important that soft rules are targeted by appropriate actions of the government specifically in the implementation phase of the innovation.

The barriers in the soft rules section could be, for example, disagreements between the actors participating in the innovation could lead to undesired innovation result or slow-down of the innovation process. In the development and implementation phase, the actions of the government should be targeted at the following actors: standardizing bodies (only from development phase), initiators/entrepreneurs, developers/industry, transport operators and lobbyists. Those actions should highlight the benefits of the road pricing scheme to stimulate positive perception of the pricing measures to be implemented. Although in the case of road pricing on the whole network producing a real-life example is hard, this is advisable and was done for passenger vehicles on a small scale⁴⁷. Also, a formal or informal road haulage industry leader should be involved to act as an advocate for the introduction of the pricing scheme. Specifically in the development and implementation phase the real time gains for road users and the reduction of externalities should be stressed.

3.3 Interaction Conditions

Weak Network Conditions. Those are characterised by weak links between the actors involved in the innovation process. Those weak links often do not allow reaching an optimal solution, because they do not allow for sufficient exploration of alternative approaches. As demonstrated in Figure 46, Figure 47 and Figure 48, actions targeting weak network conditions should be performed mostly in the development and implementation phase. In practice, actions should be taken to reduce the difficulties related to knowledge transfers and misunderstandings related to interpretations of hard rules. Specifically for this case, it might be important to ensure efficient cooperation of the different levels of governmental structures and the private partners involved.

Strong Network Conditions. Experience shows that strong network conditions can have substantial impacts on the development of an innovation case falling in the category of “Managerial, Organisational, Cultural – Market (Policy Initiatives)”. The strong network conditions should be tackled in the development and implementation phase, where they can considerably slow down the implementation of the innovation. In practice, the strong network conditions can be the different pressures or lobbying from industry organizations with the aim of either gaining certain competitive advantages, or reducing required investments or costs related to implementation of the road pricing system. Strong political will is needed from the government to counter strong network conditions.

3.4 Capabilities

Capabilities are the skills and abilities that the innovating actors possess that are relevant to the development of the innovation in focus. In this innovation case the investment in development of the capabilities were observed already in the initiation phase of the innovation process. The funded research projects indicate this. Usually the support for

⁴⁷ HLN (2011a)

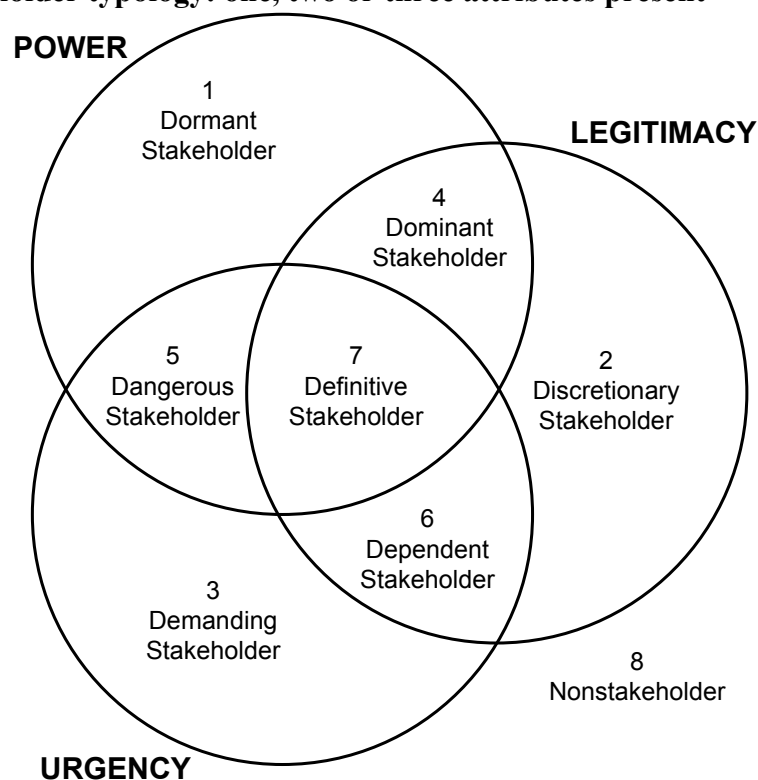
development of capabilities of the actors is needed mainly in the development and implementation phases of the innovation. In the development and implementation phase there should be a shift of focus to targeting the capabilities of the organization or consortium developing the road pricing system.

6.3.2 Framework for action

A framework for action is developed for the selected case study here. It is based on the approach developed in methodology section 3.3.2.

To recall the literature review and methodology on salience of the stakeholders (section 2.1.6 and 3.3.2) Figure 49 shows the stakeholder typology based on the three attributes which determine the salience. The presence or absence of these attributes for a stakeholder allows determining the priority of a stakeholder for managerial attention.

Figure 49: Stakeholder typology: one, two or three attributes present



Source: Mitchell *et al.* (1997)

Using the information gathered during the SI analysis on the stakeholders, the presence of attributes has been identified for the stakeholders or stakeholder groups of the road pricing innovation case. Based on the identified attributes, salience classes have been assigned to the stakeholders as shown in Table 32. The interest groups of road users and shippers are a definitive stakeholder in this innovation case. They possess the power to influence the innovation process, the legitimacy to do so and the urgency, which is an interest to influence the outcomes of the innovation.

Table 32: Attributes and salience classes of the stakeholders

Stakeholder	Attributes				Salience class*		
	Power	Legitimacy	Urgency		Latent	Expectant	Definitive
Interest groups: VAB, road transport operators	•	•	•	→			7
Interest groups: UNIZO, shippers	•	•	•	→			7
Politicians, federal level, regional level	•	•		→		4	
General public	•	•		→		4	
Research institutes		•		→	2		
Interest groups for other transport modes			•	→	3		

*Numbers refer to salience classes in Figure 49.

Politicians of different levels are dominant stakeholders for this innovation case. It means that they have the legitimacy and the power to influence the innovation process. General public has similar attributes: it has the power and legitimacy, but it does not have urgency. Research institutes have legitimacy, but have no power or urgency to influence the innovator in this situation. Interest groups for other transport modes have the urgency, but do not have the power or legitimacy.

The innovator should take the salience of the stakeholders into account when planning and implementing the innovation. In order to ensure successful implementation of road pricing in Belgium the interests of the stakeholders should be taken into account according to the salience classes determined.

Based on neo-institutionalism theory (see section 2.1.6.2), the success of an innovation depends in part at least on the ability to instil confidence in particular stakeholders that their main interests are taken into account when developing the innovation. The interests of stakeholders for the case of road pricing, which were noticed during investigation, are listed and actions to address these interests are suggested in Table 33.

When looking at the suggested actions in Table 33 the salience class of the stakeholder should be taken into account. The first column marks the importance of the interests of each stakeholder to the innovator: crucial, important or immaterial. The most important actions are the ones that target the interests of the definitive stakeholders. On the other hand, the interests of the discretionary stakeholders like research institutes or those of demanding stakeholders like interest groups for other transport modes could be ignored.

The listed suggested actions are not exhaustive and were developed taking into account inputs from the SI analysis and the suggestion of Maguire *et al.* (2004) to attach the innovation to pre-existing organizational routines and reaffirming their alignment with the values of the stakeholders.

Table 33: Interests of the stakeholders and suggested actions

	Saliency class	Stakeholder	Interest	Suggested actions
Crucial	Definitive stakeholder (7)	Interest groups: VAB, road transport operators	<ul style="list-style-type: none"> - Keep the cost of road transportation low and competitiveness high. - Minimise the impact of road pricing on the road transport operators. - In case road pricing is implemented, road users want to pass the cost increase on to the shippers/clients. 	<ul style="list-style-type: none"> - To reduce the fear of immediate threat to business the introduction of the pricing system should be planned several years in the future. This will allow the road users and their clients to take informed long-term business decisions. - The introduction of the pricing should allow passing the costs of road users on to customers. - Accompany the introduction of road pricing with compensating measures to the road users from Belgium, which would give them competitive advantage in comparison with foreign road users. Existing mechanisms should be used.
	Definitive stakeholder (7)	Interest groups: UNIZO, shippers	<ul style="list-style-type: none"> - Increase of competitiveness of local firms in the local market generated by the increased cost of transportation. - Fear that a part of the costs can not be passed on to the consumer. - Fear of loss of competitive position for certain sectors. 	<ul style="list-style-type: none"> - This stakeholder should be reassured that the price level charged will be picked so that the impact on the locally produced goods and services is positive. - To the sectors (like logistics sector) that could lose competitive position, alternative business strategies should be suggested.
Important	Dominant stakeholder (4)	Politicians, federal level, regional level	<ul style="list-style-type: none"> - Extra budget income. - Reduction of congestion for the voting car drivers. - Wish to minimize negative impacts on Belgian logistics sector. - Fear of loss of competitiveness of ports in comparison with the neighbouring countries. 	<ul style="list-style-type: none"> - The innovator should show this actor that road pricing system will generate substantial amount of revenue for the budget. - The forecast of impacts on the cargo traffic should be communicated to this stakeholder in a clear manner to show the benefits for the voters. - The politicians should be reassured that the pricing measure will not worsen the competitive position of Belgium.
	Dominant stakeholder (4)	General public	<ul style="list-style-type: none"> - Reduce the threat of implementation of road pricing for passenger vehicles. - Reduction of externalities generated by the heavy goods traffic on roads. 	<ul style="list-style-type: none"> - Public should be reassured that introduction of road pricing for heavy goods vehicles is not the first step to extending of it to the passenger vehicles. - Concrete positive impacts of road pricing should be clearly communicated.
Immaterial	Discretionary stakeholder (2)	Research institutes	<ul style="list-style-type: none"> - Interest that the development of the road pricing system is based on scientific research results. - Obtain funding to investigate the problem. 	<ul style="list-style-type: none"> - It could be beneficial to take into account the suggestions of the research institutes, because road pricing system may benefit from scientific inputs. The interests of this stakeholder group can be ignored.
	Demanding stakeholder (3)	Interest groups for other transport modes	<ul style="list-style-type: none"> - Interest to ensure that the pricing policies that are applied to road transportation put it in unfavourable position. 	<ul style="list-style-type: none"> - The interests of this stakeholder group can be ignored.

CHAPTER 7 Discussion and conclusions

This research deals with the development of viable policy measures that can be successfully implemented using a case study aimed at tackling congestion on port hinterland links. A three-step framework, which includes cost-benefit analysis approach, but also the analysis of non-financial parameters, is developed. As the first step, impacts simulation is done, because the impacts of a proposed policy mechanism can differ depending on factors like design of the measure, specific infrastructure network layouts, characteristics of competing modes and existing policies in place. As the second step of the approach, a social cost-benefit analysis of the measure is performed. As the third step, the Systems Innovation approach, which focuses on the interactive mechanisms that shape the emergence and diffusion of innovations, is used.

This chapter discusses how this research contributes to the existing knowledge and approaches in the field, discusses the performance of the methodology and the observations from the case study (in 7.1). It shows (in 7.2) what the implications of the research results are at scientific level, political level and in practice. The conclusions are drawn in 7.4.

7.1 Discussion

7.1.1 The contribution of this research

The value added of this research becomes apparent in the light of the literature review described in CHAPTER 2. The literature review reveals the existence of two different fields related to the research question investigated in this thesis.

On one hand, there is the literature on innovations, which defines them (Hesselbein *et al.* (2002)), describes the typology of innovations (Garcia and Calantone (2002)), investigate the innovation processes (Van de Ven *et al.* (1999)) and the interactions within the innovation systems (Arnold *et al.* (2001)) where those processes occur.

On the other hand, there is another field of knowledge that develops the measures that could be implemented for tackling congestion problems in general, also applicable on port hinterland links.

One could consider the infrastructure measures, which include expansion of the existing infrastructure capacity. Literature review shows that infrastructure expansion can have unwanted effects (Thomson (1977)) and it can be impractical in many urban areas (Chen and Bernstein (2004)). Also, there is the problem of induced demand – increase of new vehicle traffic that would not have occurred at all without the capacity improvement (Mokhtarian *et al.* (2002)).

Also for consideration is a broad range of road pricing measures, which include first-best (marginal cost) and second-best measures. In practice according to Nash and Sansom (2001) marginal cost pricing would require highly differentiated pricing systems which would be expensive in implementation and confusing to users. Since the 90ties second-best measures have more attention in the literature, because, according to Verhoef (2002), in practice often only second-best solutions are considered.

What the literature does not focus on is the development of measures that ensure their optimal path of implementation. It is obvious, that in an imaginary world where the policy measures can be implemented without any opposition or interests of groups of society, the measures described above could be efficient. However, in reality it might be that, if the practical implementation path is taken into account, better approaches can be developed.

Therefore, this research shows a way to bring the two fields of knowledge described above together, which creates synergies. With the help of the methodology proposed in this research measures that are efficient in real-world situations can be developed. This applies to the development, but also to the implementation and further exploitation of the developed policy measure.

Table 34 shows the main contributions of this research, including the component of the methodology that the contribution relates to and where the outputs are reported.

Table 34: Main contributions of the research

Contribution relates to	Contribution of this research	Reported in
Developed methodology	<ul style="list-style-type: none"> • A new methodology suitable for developing and implementing transport policy innovations is developed and validated. 	<ul style="list-style-type: none"> • Methodology, CHAPTER 3 • Application, CHAPTER 4, CHAPTER 5 and CHAPTER 6
Impacts simulation	<ul style="list-style-type: none"> • Detailed results on impacts of road pricing on road network in Belgium, under different economic and port growth assumptions. 	<ul style="list-style-type: none"> • Methodology, section 3.1 • Impacts simulation, CHAPTER 4
Cost-benefit analysis	<ul style="list-style-type: none"> • An approach for performing social cost-benefit analysis of innovative process is developed. It takes into account the economic characteristics of an innovation with focus on different participating actors. • A success algorithm is developed, which allows evaluation of possible outcomes of the innovation investigated. • An application is done for the case of road pricing in Belgium. 	<ul style="list-style-type: none"> • Methodology, section 3.2 • Cost-benefit analysis of innovative process, CHAPTER 5
Systems innovation analysis	<ul style="list-style-type: none"> • Systems innovation analysis is included in the developed methodological framework in a way, which allows practical application of it to innovation cases under development. • Validation of the systems innovation approach with application to the Belgian road pricing case is done. • Concrete actions for the case of road pricing in Belgium are suggested. 	<ul style="list-style-type: none"> • Methodology, section 3.3 • Systems innovation analysis, CHAPTER 6

7.1.2 Performance of the methodology

The application of the developed methodology has allowed evaluating its advantages and detecting the issues to consider when the methodology is applied to case studies in the future.

One of the main advantages of the proposed methodological framework is its transferability. Although the methodology developed in this research was developed to identify a successful approach to tackle congestion on port hinterland links, the methodology could also be applied for testing other innovations. One would always start with an innovation, which would have impacts on the economy which can be determined. Then, the application of the methodology would allow determining whether the innovation is favourable and in which areas the steps should be taken to successfully implement it.

In cases where the uncertainty about the details of the project and its outcomes are too high, which makes the cost-benefit analysis impossible, the proposed methodology allows overcoming this problem. The SI approach that is used in the methodology allows working on innovation cases where there is lack of quantifiable data.

The ability to tackle the interests of different groups of society is another of the advantages of the methodology. The methodology allows including in the analysis the impacts that an innovation would have on the different groups of society. This can be done both in the cost-benefit analysis (second stage of the methodology) and in the SI analysis (third stage of the methodology). Such detailing in the analysis provides better results than aggregate approach would. It also empowers the innovator by providing a set of suggestions tailored to tackle each of these social groups to ensure a successful implementation of the innovation.

One must take into account for future applications of the developed methodology, that the outcomes of the analysis can be susceptible to the availability and the quality of the input data. For example, for SI analysis, great care should be taken when choosing the input case studies, because these would have great influence on the conclusions that one would make. The input case studies⁴⁸ provide the data for creating matrixes that characterise system success conditions, which are then used for application to the target case study, which in this research is the Belgian road pricing case. In this research this limitation was tackled by carefully selecting the case studies within the transportation field that, like the case analysed, fall in the same category of “Managerial, Organisational, Cultural – Market (Policy Initiatives)” innovations.

Often the impact simulation can be a very time-consuming process, which involves a lot of experience and technical knowledge in the field of modeling. Therefore, if possible, the use of an externally-developed model for running the necessary scenarios would be advisable. This approach was taken in this research.

The developed methodology currently is more focussed on the innovations that have wider impacts on the society, which require involvement from the government at least on some level. Further research could extend this methodology for application in business environments or non-governmental organizations at smaller scale.

7.1.3 Observations from the case study

The case study served for validation of the methodology, to demonstrate that it can be applied in practice. The application also provided important results for the case study of road pricing in Belgium. The proposed methodological framework was applied to the analysed case study

⁴⁸ In this research cases of cabotage liberalization, Eurovignette directive, ECMT three trip restriction, variable speed limits and others from Arduino *et al.* (2011a).

in CHAPTER 4, CHAPTER 5 and CHAPTER 6, which correspond with the different stages of the methodology. The main observations, grouped by stages of the methodological framework, are discussed below.

From stage 1

It was noted in the simulations that the impacts of a pricing measure on a road network are not homogenous. One scenario could have different or even adverse impacts at different locations of the road network. This is logical, and is also confirmed in practice by research from Germany (see Martino *et al.* (2008), p.27) on the LKW-maut system, which shows increases of traffic on minor roads as a result of road pricing on highways.

The synergies that the design of integrated transport strategies brings have been previously shown in detail by May and Roberts (1995). The impacts simulation confirmed that sets of measures have greater effects than single measures. This was clearly demonstrated by scenarios 8, 11 and 12 where a set of combined policy measures were enacted.

On the main port hinterland links, like the E313 motorway for the port of Antwerp, there are strong impacts of assumptions on port growth. The increased/decreased port throughput assumptions had an influence both on incoming and outgoing flows. This is logical, as an increase in turnover at the port is related to an increase of traffic on the hinterland links of a port. For the port of Antwerp this was confirmed by the data obtained from the Flemish Traffic Centre, Aronietis *et al.* (2009).

The findings from the first stage of the investigation showed the nature of impacts that a road pricing could have on a road network. When tackling similar cases, an innovator should expect that the impacts are not the same at the different locations of the road network. Playing with sets of policy measures in the modeling stage should allow producing more efficient policies. The sensitivity of the cargo flows on the road network to the port growth dynamics should also be taken into account.

From stage 2

The application of the cost-benefit analysis for determining the outcomes of implementation of the road pricing scenario showed positive net impacts of the project, which is an indicator that the innovation is likely to succeed.

An overview of the cost-benefit appraisal approaches is given by Grant-Muller *et al.* (2001). Some specific examples of application include Rotaris *et al.* (2010) and Eliasson (2009). In comparison to these, the added value of this step in the developed methodology is that in this research the cost-benefit analysis treats the actors individually. This means that the impacts of the innovation for each of the actors can be assessed.

The investigation of the case study of road pricing in Belgium allows observing the costs and benefits for all the involved actors. The analysis shows that the most benefits, which come from time savings and reduction of externalities related to cargo traffic volumes, are enjoyed by the individuals. For companies that are road users the benefits come from time savings and consumer surplus, but those do not outweigh the toll that has to be paid. The government bares the system development costs, which it covers with toll revenues.

It is clear that the congestion problems on Belgian motorway network cannot be solved by pricing measures that are applied only to heavy goods transport, because the other main

contributors to the congestion problem are the passenger vehicles. There are still benefits from implementation of the road pricing for heavy goods vehicles. It would be more efficient if the pricing was applied to all road users. Unfortunately, this is currently unlikely for political reasons.

From stage 3

In the third stage of the research the strong role of the government in the innovation process was confirmed again, similar to the results of the cost-benefit analysis. This is not a surprise, as it arises from the nature of the case study and the fact that the government itself is the innovator. A similar strong involvement of the government has been observed in practice in other network-wide implementations in Switzerland (see Balmer (2003)), Austria and Germany (see Doll and Link (2007); Broaddus and Gertz (2008)).

The outputs of the SI analysis in this stage of the methodology are important in practice, because they provide concrete indications which actions between actors and the institutional environment are required to establish the successful implementation of the innovation; in this case road pricing. The methodology extends the work of Woolthuis *et al.* (2005), who focussed on systematic innovation failure. In this research, based on Arduino *et al.* (2011b), the modified approach allows generation of policy interventions that would allow steering the innovative process to a successful outcome, possibly, in a more efficient way.

7.1.4 Results of the propositions tests

In the initiation stage of the research, a set of propositions was defined. During the research those were tested:

P1: Implementation of a transport policy measure to tackle congestion problems requires tailoring a custom solution, which includes a measure or a set of measures, for a particular implementation situation.

This proposition was confirmed with the literature review, which shows that the impacts of a policy measure and its success can differ depending on where it is implemented. Therefore, each implementation situation requires a custom approach to reach the goals of the policy in an optimal way.

P2: Conditions that determine successful implementation of innovative concepts, like measures for tackling congestion on port hinterland links, exist and can be identified.

This proposition was confirmed in the literature review, and also with the application of the developed methodological approach. The literature, like Hauknes and Nordgren (1999), Smith (2000), Woolthuis *et al.* (2005) and Edquist and Chaminade (2009), show that conditions influencing the innovation success or failure can be determined. The application of the developed methodology confirms it in this research with the cost-benefit and SI approach.

P3: Pricing measures are efficient and can be applied for decreasing freight traffic intensity on road networks in port hinterland situations where alternative transport modes exist. They reduce demand and promote mode shift.

P4: In port hinterland situations, transport policy measures (including different pricing instruments) with similar consequences reinforce each other. Those synergies can be exploited by the developing complex sets of policy measures for practical implementation.

Both, proposition P3 and P4, were tested with the help of model-based analysis. The efficiency of the pricing measures on the road network was demonstrated in the impacts simulation, where mode shift was observed towards alternative modes. The effects of pricing policies seemed stronger when enacted in packages, which suggests this can be exploited in practical implementation situations.

P5: The proposed methodological framework is applicable for testing the success or failure of innovations. It allows developing innovations that are easier to implement and producing practical suggestions for optimising the innovation path of innovation cases in practice.

This proposition was confirmed with successful application of the proposed methodology to the case study of road pricing in Belgium in CHAPTER 4, CHAPTER 5 and CHAPTER 6. It proved to be able to determine whether an innovation is likely to succeed, and also able to provide concrete actions to facilitate the practical implementation of the innovation.

7.2 Implications

The methodology developed and the results of the research have implications at the scientific level, political level and in practice.

At the **scientific level**, in the field of transport economics, because of the approach developed in this research, new techniques for developing second-best approaches might appear. The focus might shift from “efficient” to “implementable”. In other words, the goal will become developing optimal policy measures that are fit for implementation, rather than ones that are efficient, but not necessarily implementable.

The development of “implementable” policies is important, because the goal of any policy is to reach the desired impacts that it was designed to achieve. Without implementation no policy can reach its primary goal. Therefore, the developed methodology in this thesis is a contribution to reach the goal of successful implementation of different policies, specifically the ones addressing issues in the field of transport.

The approach that was developed and validated in this thesis allows increasing the value of scientific contributions to the society. The developed methodology allows the researchers to develop policies that are better fit for implementation. This is because the implementation path and the interests of the stakeholders are already taken into account. Therefore, the scientific contributions created with this methodology can be of greater value to the society.

This research demonstrates that a good or optimal policy measure is not always the most efficient when in addition to its other characteristics the implementation path is taken into account. A sub-optimal policy in a traditional sense that can be implemented and reaches the pre-set policy goals or benchmarks could be the one to aim for.

At **political level**, the knowledge developed here should allow for greater complexity and wider scope of the policies in transport that governments enact at different levels. This should enable preventing the inefficiencies or contradictory impacts that some current policies suffer from. The development of more complex policies that combine measures would make the development of contradictive policies less likely, as more all-inclusive policy bundles would be created.

Also, the methodological approach developed in this research allows generating results with a high level of practical applicability. Governments of different levels might be interested in the application of the methodological approach, because of the benefits it provides. It empowers the decision makers with information at three levels.

First, it allows obtaining information on detailed impacts of the measure considered, and, possibly, optimize its design for the specific situation that it would be applied to. Here, an approach with different scenarios modeling cost and different other design parameters could be used.

Second, it gives them the data concerning the monetized impacts of the measure to the different actors involved, including the public, companies and the innovator himself. If detailed data are available, the listing of involved actors can be expanded, for example, going into detail for different groups of population depending on the number of the vehicles in the household and so on.

Last, the SI analysis allows producing a set of areas for suggested actions at each stage of the development of the innovation. This would allow tailoring support actions for successful market uptake of measures to be implemented. This would also shorten the timeframe that the innovation path takes, because the most suitable actions could be chosen.

The developed methodology in this research was applied in the field of transport – for the analysis of a measure tackling congestion on port hinterland links. However, **in practice** the areas where the approach could be applied are not limited to the field of transport. It can be done for any innovation case, where there is an important innovation to be implemented with involvement of the government, which could have important impacts on different actors in the economy.

Examples of application of the developed approach could include, but also extend beyond the field of transport. Those could be the development of infrastructure of local (bicycle paths, hospitals, etc.) or national (bridges, railway lines, etc.) importance, but also policies (restrictions of truck driving hours at certain points of the road network, adjustments to vehicle taxation legislation, etc.). Such application would change the approaches that are applied in the first stage of the developed methodological framework, but the second stage with the cost-benefit analysis and the third stage with systems innovation analysis would stay the same.

Also, the results of the case study investigation of this research are valuable in practice. Currently, there is a discussion in Belgium about the possible implementation of road pricing on motorway network at least for one vehicle category – the heavy goods vehicles. This has been a hot topic in political debate in recent years. This current situation is analysed as the case study in this research, producing relevant results. Those results could be useful for practical development and implementation of road pricing in Belgium after a political decision has been made.

7.3 Suggestions for future research

Further applications of the developed methodology could also be done for products or projects that companies and non-governmental organizations introduce. This is because the structure of costs and benefits for the society and the involved actors is similar. This would

allow applying the developed cost-benefit analysis and determining the likely innovation path, and working with systems innovation analysis to develop optimal actions during the different temporal stages of the innovation for facilitating its implementation. In order to do this, depending on the specific case investigated, further research might be required.

This research deals mainly with policy innovations. The case study investigated is also a policy innovation. It is clear that in the real world most of the innovations are not policy innovations. In order to target other types of innovations with the developed approach, it would be useful to investigate its applicability to those types of innovations. This could extend the applicability of the approach to business environments for products that companies introduce for the first time or in a new market. It would also be interesting to investigate the applicability of the approach for innovation processes of non-governmental organizations.

Future research could also elaborate further the methodologies that are the building blocks for the approach that was developed in this research. For example, in the impacts simulation of this research only the direct impacts of the road pricing case study are included. The indirect impacts, like impacts on regional competitiveness, are not investigated. Future research, particularly for large-scale innovation cases because of their substantial impacts on the economy, could incorporate these impacts. Also, the cost-benefit analysis could be extended to include more detailed cost and benefit structure.

7.4 Conclusions

This doctoral research set out to search for a solution to a problem that most of the ports have faced in the last decades. Due to increased turnover the goods traffic flows on the dominant hinterland transport mode increases and leads to congestion at certain times of the day. In the context of freight traffic, congestion results in extra costs related to time, uncertainty about arrival times, waste of fuel, increased wear of vehicles and other negative effects, including those on the environment. Also, the increased congestion on the land side negatively affects the competitive position of ports. In this situation, governments and port authorities are under pressure from the industry to act and come up with solutions. But at the same time governments have to deal with financial constraints and the political unviability of the available solutions. Literature provides a range of applicable measures for tackling the congestion problems, but in practice the implementation almost always faces barriers.

Taking the situation described above into account, this research developed a methodology which focuses on the implementation process of applicable measures, with the aim of identifying an optimal implementation path with a high chance of success. The validation of the developed methodology was done with the help of a case study of introduction of a road pricing scenario for heavy goods traffic.

The general objective of this research was to increase the field of knowledge by developing a methodology that links the knowledge available on the measures for alleviating road congestion with the approaches that exist for reaching successful implementation of the innovations. The aim was to ensure that the results of this research are applicable by policy makers at different governmental levels for introduction of the measures aiming at reducing road network congestion.

The two main contributions of this research help reaching the objective of this research: first contribution is the developed methodology, second are the outputs of the investigation of the

case study. The developed methodology serves as basis for investigation of the case study, but its applicability in transport and, possibly, other fields makes it attractive for use in future research. The investigation of the case study validates the methodology and provides outputs for a real case study that is currently in the beginning of the innovation initiation stage. The research demonstrates an elegant approach to tackle the problem using the proposed methodological framework.

The political and practical dimension of the research results makes them relevant to governments and other innovators for applications in transport and other fields. The results of this research contribute to the development of more efficient contemporary solutions for problems that transport policies are called to solve.

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Annex 1: Key logistics drivers

Table 35: Key logistics drivers

KEY DRIVER	TYPE OF FACTOR	REFERENCES
Economic growth / GDP growth / Income per capita	Macro factor	Accenture (2001); Akashi (2006); Bertrand and Rood (2000); Bleijenberg (2002); De (2007); European Commission (2007); Eijkelenbergh <i>et al.</i> (2004); Grammenos (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Jensen (2007); Matzos <i>et al.</i> (2004); Matzos <i>et al.</i> (2003); OECD (2007); OECD (2006); Scenario Study Team (2006); Singh (2004); Institute of Shipping Analysis, Göteborg <i>et al.</i> (2006); Timms <i>et al.</i> (2005)
Environmental Policy and pricing externalities	Macro / Industry factor	Akashi (2006); Banister <i>et al.</i> (2000b); Banister <i>et al.</i> (2000a); De (2007); Dalla <i>et al.</i> (2001); Eijkelenbergh <i>et al.</i> (2004); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Jensen (2007); Matzos <i>et al.</i> (2004); Matzos <i>et al.</i> (2003); Ministerio de Fomento de Espana (2004); OECD (2006); Sauer (2002); Queensland Department of Transport and Main Roads (1999); Scenario Study Team (2006); Singh (2004)
Policy measures	Macro / Industry factor	Banister <i>et al.</i> (2000b); Bertrand and Rood (2000); Bleijenberg (2002); De (2007); Dalla <i>et al.</i> (2001); Eijkelenbergh <i>et al.</i> (2004); Grammenos (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Jensen (2007); Jespersen and Nielsen (2003); Matzos <i>et al.</i> (2003); OECD (2006); Queensland Department of Transport and Main Roads (1999); Singh (2004); Institute of Shipping Analysis, Göteborg <i>et al.</i> (2006)
Production and distribution patterns	Industry factor	Akashi (2006); Banister <i>et al.</i> (2000b); Banister <i>et al.</i> (2000a); Bleijenberg (2002); Grammenos (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Jespersen and Nielsen (2003); Lemoine and Skjoett-Larsen (2004); Leleur <i>et al.</i> (2004); McKinnon and Woodburn (1996); McKinnon (2002); Nielsen <i>et al.</i> (2003); Singh (2004)
Technological developments including transport and fuel technology	Macro / Industry factor	Accenture (2001); Akashi (2006); Banister <i>et al.</i> (2000a); De (2007); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Jensen (2007); Matzos <i>et al.</i> (2004); Sauer (2002); Queensland Department of Transport and Main Roads (1999); Ringland (2004); Scenario Study Team (2006); Singh (2004); Timms <i>et al.</i> (2005)

KEY DRIVER	TYPE OF FACTOR	REFERENCES
Infrastructure policy and developments / Quality of transport services	Industry factor	Akashi (2006); Dalla <i>et al.</i> (2001); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Jespersen and Nielsen (2003); Ministerio de Fomento de Espana (2004); OECD (2006); Sauer (2002); Queensland Department of Transport and Main Roads (1999); Singh (2004); Institute of Shipping Analysis, Göteborg <i>et al.</i> (2006); Timms <i>et al.</i> (2005)
Global trade / trade patterns	Macro factor	Akashi (2006); European Commission (2007); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Jespersen and Nielsen (2003); McKinnon (2002); Nielsen <i>et al.</i> (2003); OECD (2007); Scenario Study Team (2006); Singh (2004); Institute of Shipping Analysis, Göteborg <i>et al.</i> (2006)
Energy and oil prices	Macro / Industry factor	De (2007); European Commission (2007); Grammenos (2002); Jensen (2007); Matzos <i>et al.</i> (2004); Matzos <i>et al.</i> (2003); OECD (2007); OECD (2006); Sauer (2002)
Demographic changes	Macro factor	Accenture (2001); Banister <i>et al.</i> (2000a); Bertrand and Rood (2000); Bleijenberg (2002); De (2007); OECD (2006); Ringland (2004); Singh (2004); Timms <i>et al.</i> (2005)
Geopolitical situation	Macro factor	Accenture (2001); Banister <i>et al.</i> (2000a); Bertrand and Rood (2000); Eijkelenbergh <i>et al.</i> (2004); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Jensen (2007); Singh (2004); Timms <i>et al.</i> (2005)
Labour market	Macro factor	Akashi (2006); De (2007); European Commission (2007); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); OECD (2007); Scenario Study Team (2006); Singh (2004)
Changes in demand taste / trends	Macro factor	Akashi (2006); Banister <i>et al.</i> (2000b); European Commission (2007); Jespersen and Nielsen (2003); Leleur <i>et al.</i> (2004); Scenario Study Team (2006); Singh (2004)
Globalisation	Macro factor	Banister <i>et al.</i> (2000b); Grammenos (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); OECD (2007); Singh (2004)
Social implications	Macro factor	Eijkelenbergh <i>et al.</i> (2004); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2002); Institut für Wirtschaftspolitik und Wirtschaftsforschung (DE) <i>et al.</i> (2000); Singh (2004)
Security matters	Macro / Industry factor	Bertrand and Rood (2000); Jensen (2007)
Urban development	Macro factor	Queensland Department of Transport and Main Roads (1999); Scenario Study Team (2006)

Source: Aronietis *et al.* (2009)

Annex 2: Types of innovations

A review of literature by Garcia and Calantone (2002) gives a good overview and reveals the following categorizations from different sources:

- **eight categories** – reformulated / new parts / remerchandising / new improvements / new products / new user / new market / new customers, [Johnson and Jones C. (1957)];
- **five categories** – systematic / major / minor / incremental / unrecorded [Freeman (2011)];
- **tetra-categorization** – incremental / modular / architectural / radical [Henderson and Clark (1990)], niche creation / architectural / regular / revolutionary [Abernathy and Clark (1993)], incremental / evolutionary market / evolutionary technical / radical [Moriarty and Kosnik (1990)], incremental / market breakthrough / technological breakthrough / radical [Chandy and Tellis (2000)], incremental / architectural / fusion / breakthrough [Tidd (1995)];
- **triadic categorization** – low innovativeness / moderate innovativeness / high innovativeness [Kleinschmidt and Cooper (1991)], incremental / new generation / radically new [Wheelwright and Clark (1992)] and,
- **dichotomous categorization** – discontinuous / continuous [Anderson and Tushman (1990), Robertson (1967)], instrumental / ultimate [Grossman (1970)], variations / reorientations [Normann (1971)], true / adoption [Maidique and Zirger (1984)], original / reformulated [Yoon and Lilien (1985)], innovations / reinnovations [Rothwell and Gardiner (1988)], radical / routine [Meyers and Tucker (1989)], evolutionary / revolutionary [Utterback (1994)], sustaining / disruptive [Christensen (1997)], really new / incremental [Schmidt and Calantone (1998), Song and Montoya-Weiss (1998)], breakthrough / incremental [Rice *et al.* (1998)], and radical / incremental [Balachandra and Friar (1997), Freeman (1994), Atuahene-Gima (1995), Kessler and Chakrabarti (1999), Lee and Na (1994), Schumpeter and Opie (1934), Stobaugh and Gagne (1988)].

