

Beleidsondersteunende paper

STRATEGIC FREIGHT MODEL FLANDERS: ASSESSMENT, DEVELOPMENT AND APPLICATIONS

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STRATEGIC FREIGHT MODEL FLANDERS: ASSESSMENT, DEVELOPMENT AND APPLICATIONS

Het Steunpunt Goederen- en personenvervoer doet beleidsrelevant onderzoek in het domein van transport en logistiek. Het is een samenwerkingsverband van het Departement Transport en Ruimtelijke Economie van de Universiteit Antwerpen en het Departement MOBI – Transport en Logistiek van de Vrije Universiteit Brussel. Het Steunpunt Goederen- en personenvervoer wordt financieel ondersteund door de coördinerende minister Ingrid Lieten, viceminister-president van de Vlaamse Regering en Vlaams minister van Innovatie en Overheidsinvesteringen, Media en Armoedebestrijding en Hilde Crevits, Vlaams minister van Mobiliteit en Openbare Werken, de functioneel aansturende en functioneel bevoegde minister.

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Management samenvatting

Het Steunpunt Goederenstromen werkt mee aan een onderbouwing van een Vlaams beleid dat streeft naar duurzame logistiek. Dat houdt voor goederenvervoer in dat de verplaatsing daarvan op een wijze gebeurt die de hinder voor het milieu, de samenleving en de economie zo laag mogelijk houdt. Hierbij is het belangrijk om een kwantitatieve inschatting te kunnen maken van de gevolgen van acties om duurzame logistiek uit te bouwen. Concreet kan daarvoor gebruik gemaakt worden van een rekenmodel, dat het mogelijk maakt om via scenario's de kwantitatieve effecten (output) te berekenen in het geval een aantal basisvariabelen (input) wijzigen. Het Strategisch Vrachtmodel Vlaanderen is een rekenmodel om de effecten op het goederenvervoer op het Vlaamse netwerk te berekenen.

Het Strategisch Vrachtmodel Vlaanderen werd ontwikkeld door K+P Transport Consultants, Tritel en MINT op vraag van de Afdeling Verkeerscentrum van het Departement Mobiliteit en Openbare Werken van de Vlaamse overheid¹. In deze beleidsondersteunende paper wordt de rol van het Steunpunt Goederenstromen in relatie tot het Strategisch Vrachtmodel Vlaanderen beschreven. De vermelde activiteiten hebben betrekking op de onderzoeksperiode 2007-2011.

Tijdens de onderzoeksperiode heeft het Steunpunt Goederenstromen verschillende werkversies van het Vlaams Vrachtmodel getest en beoordeeld. Hierbij werd gebruik gemaakt van verschillende analytische en ondersteunende methodes, zoals bijvoorbeeld kalibratie, sensitiviteitsanalyse en de analyse van gebruikte kostenfuncties. De methodologie heeft geleid tot suggesties voor een verdere verbetering en ontwikkeling van het Vrachtmodel. Een aantal verbeteringen werden reeds doorgevoerd in recentere versies van het Vrachtmodel.

In deze paper wordt getoond dat het mogelijk was om het Strategisch Vrachtmodel Vlaanderen te gebruiken in het kader van volgende toepassingen:

- In onderzoek rond "watergebonden bedrijventerreinen" werd een methode voorgesteld om met gebruik van het Vrachtmodel een indicatie te geven van de toekomstige behoefte aan (additionele) watergebonden oppervlaktes;
- In een "tactische studie E313" werd het Vrachtmodel ingezet om een aantal specifieke maatregelen te onderzoeken die een effect hebben op de trafiek op de E313;

¹ In 2012 vond een wijziging plaats in de samenstelling van het consortium. Het nieuwe consortium bestaat uit de partners MINT, Significance en Progtrans.

- In het onderzoek rond “sluis Blauwe Kei” werd getoond hoe het Vrachtmodel kan ingezet worden om de effecten van infrastructuurwijzigingen in te schatten, in dit geval de aanpassing van sluisen voor de binnenvaart;
- Tot slot wordt geïllustreerd hoe het Strategisch Vrachtmodel Vlaanderen kan ingezet worden voor de beoordeling van de invoering van rekeningrijden in Vlaanderen.

De vlotte samenwerking tussen de verschillende partners (Afdeling Verkeerscentrum, MINT, K+P Transport Consultants en het Steunpunt Goederenstromen²) in de onderzoeksperiode 2007-2011 maakte het mogelijk om de werkversies van het Strategisch Vrachtmodel Vlaanderen te beoordelen, te testen, verder te ontwikkelen en toe te passen. Op basis van dit onderzoek heeft het Steunpunt Goederenstromen een aantal conclusies opgesteld om toekomstig onderzoek te ondersteunen.

Een onderscheid werd gemaakt tussen 2 types conclusies: vanuit een modelmatig standpunt (“hoe kan de theoretische onderbouwing van het Vlaams Vrachtmodel verbeterd worden?”) en vanuit het standpunt van de gebruiksvriendelijkheid (“hoe kan een gebruiker op een efficiënte manier werken met het Vlaams Vrachtmodel?”)

Conclusies vanuit een modelmatig standpunt:

- Er kan overwogen worden om verder onderzoek uit te voeren omtrent de relatie tussen de kost van vervoer en de prijs van vervoer;
- Er kan overwogen worden om een validatietest uit te voeren op het moment dat het basisjaar (2004) gewijzigd wordt. Vertrekkende van het oude basisjaar kan dan een simulatie uitgevoerd worden om de goederenvolumes voor het nieuwe basisjaar te voorspellen;
- Er kan overwogen worden om verder onderzoek uit te voeren omtrent de effecten van congestie op de vervoerswijzekeuze, niet alleen voor wegvervoer, maar tevens voor binnenvaart en spoorvervoer;
- Er kan overwogen worden om verder onderzoek uit te voeren omtrent de opname van kwalitatieve variabelen in het Strategisch Vrachtmodel Vlaanderen (bijvoorbeeld waarde van tijd); op dit moment wordt enkel rekening gehouden met monetaire kosten;
- Het is belangrijk dat de Vlaamse zeehavens zo realistisch mogelijk opgenomen zijn in het Strategisch Vrachtmodel Vlaanderen. Dit vereist de medewerking van de Vlaamse zeehavens bij de verdere ontwikkeling van het Strategisch Vrachtmodel Vlaanderen;
- Bijkomend onderzoek is nodig om een beter zicht te krijgen op containerstromen op het Vlaams grondgebied;
- Er kan overwogen worden om verder onderzoek uit te voeren omtrent de opname van emissie-submodellen in het Strategisch Vrachtmodel Vlaanderen;
- Geïntegreerde rekeninstrumenten en modellen kunnen leiden tot een betere ondersteuning van duurzame havenstrategieën;
- De kalibratie en validatie van het spoorvervoer in het Strategisch Vrachtmodel Vlaanderen dient bijkomende aandacht.

² Hiertoe was telkens een nauwe samenwerking met onderzoekers van het Departement Transport en Ruimtelijke Economie, Universiteit Antwerpen.

Conclusies vanuit het standpunt van de gebruiksvriendelijkheid van het Strategisch Vrachtmiddel Vlaanderen:

- Een uitgebreide en up-to-date handleiding is gewenst voor de gebruikers van het Strategisch Vrachtmiddel Vlaanderen, inclusief een overzicht van gebruikte formules en methodes;
- In de vermelde handleiding dienen tevens een aantal praktische voorbeelden opgenomen te worden;
- Het zou handig zijn om een software toepassing te creëren bovenop het Strategisch Vrachtmiddel Vlaanderen, waarbij enkel de schermen getoond worden die een gebruiker nodig heeft (bijvoorbeeld: schermen met inputvariabelen). Dit kan ook in de praktijk gebracht worden door de creatie van een internettoepassing waarbij de gebruiker een aantal schermen kan invullen, waarna de informatie wordt doorgestuurd naar de Afdeling Verkeerscentrum;
- Er kan overwogen worden om een lijst op te stellen met mogelijke output van het Strategisch Vrachtmiddel Vlaanderen;
- Er kan overwogen worden om de gebruiker van het Strategisch Vrachtmiddel Vlaanderen een aantal standaardscenario's te bezorgen, die onmiddellijk kunnen gebruikt worden. Dit kan ook het voorzien van alternatieve, onderliggende netwerken inhouden;
- Voor sommige toepassingen kan geadviseerd worden om de mogelijkheid te bieden te werken met gedifferentieerde kostenfuncties (vb. sommige corridors worden gekenmerkt door aparte kostenfuncties).

Vanaf 2012 wordt het Steunpunt Goederenstromen opgevolgd door het Steunpunt Goederen- en personenvervoer. Het nieuwe Steunpunt zal de verdere ontwikkeling van het Strategisch Vrachtmiddel Vlaanderen eveneens ondersteunen, gegeven het belang ervan voor het beleidsondersteunend onderzoek voor het goederenvervoer in Vlaanderen.

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List of abbreviations

DG TREN/MOVE	Directorate-General for Mobility and Transport (European Commission)
e.g.	Exempli Gratia (For Example)
et al.	Et alii (and others)
FMF	Freight Model Flanders (Vrachtmodel Vlaanderen)
GDP	Gross Domestic Product
GIS	Geographic Information System
ha	hectare
IPTS	Institute for Prospective Technological Studies; Joint Research Center
IWW	Inland WaterWays
LAMBIT	Location Analysis Model for Belgian Intermodal Terminals
MOBER	Mobility effect report (Mobiliteitseffectenrapportage)
NST	Nomenclature uniforme des marchandises pour les Statistiques de Transport (Nomenclatuur VervoerStatistiek)
NUTS	Nomenclature of territorial units for statistics (Nomenclatuur van territoriale eenheden voor statistiek)
PLANET	PLANbureau Economy and Transport
SIMBA	Discrete event simulation model for inland navigation
tkm	Tonne-kilometre
VC	Kenniscentrum Verkeer en Vervoer, Afdeling Verkeerscentrum, Departement Mobiliteit en Openbare Werken
Vkm	Vehicle-kilometre
VITO	Vlaamse Instelling voor Technologisch Onderzoek
VUB	Vrije Universiteit Brussel

1 Introduction

As stated in the mission of the Research Centre on Commodity Flows, a policy of the Flemish government should be founded that aims at 'sustainable logistics'. Applied to transport, sustainability implies that persons and goods should be transported in a manner that reduces the burden caused to the environment, society and the economy.

It is also important to be able to quantify actions that can support this mission. One of the options is to use a simulation tool, which makes it possible to calculate the quantitative effects (output) when changing some indicators (input), on the basis of scenarios. For example: what is the effect of a changed economic growth (input) on transport flows (output).

At the request of the public authorities Afdeling Verkeerscentrum, Departement Mobiliteit en Openbare Werken (VC) of the Flemish Government, a new Freight Model for Flanders was developed by K+P Transport Consultants, Tritel and MINT from the year 2006 on.

In this paper, the role of this Strategic Freight Model Flanders (FMF) in relation to Research Centre is described. The activities mentioned refer to the research period 2007-2011. In section 2, a description of the FMF is given, also pointing out what the specific role of Research Centre is. The section ends with an overview of relevant freight models for Flanders.

The Research Centre has tested and assessed several working versions of the FMF, by using several analytical and supporting methods, such as calibration and sensitivity analysis. The several methods (described in section 3) have led to suggestions for further improvement and development of the FMF during the research period 2007-2011.

Within the Research Centre, the FMF was used for several research projects, including effects of infrastructural changes and effects of pricing. An overview is given in section 4.

During the research period 2007-2011, intense cooperation between the Research Centre, VC, MINT and K+P Transport consultants, has led to the possibility to assess, develop and apply the Strategic Freight Model Flanders. On the basis of the research, it is possible to make some conclusions about future approaches in section 5.

2 Freight models in Flanders

In section 2.1, a brief model description of the Strategic Freight Model Flanders is given, followed by a description of the role of the *Research Centre on Commodity Flows* in the period 2007-2011 (section 2.2). An overview of relevant (other) freight models for Flanders is given in section 2.3, also including current trends in freight modeling and relevant points of interest.

2.1 Strategic Freight Model Flanders: description

Freight transport models are mathematical-empirical models that describe and explain the performance of a freight transport system. They also allow making predictions about the future assuming that certain changes are made to that system in consequence of, for example, exogenous developments or policy decisions (De Jong and Van de Riet, 2004). As such, they can be used to determine the direct and indirect impact of new infrastructure projects (Tavasszy, 2003).

At the request of the public authorities (VC), a new FMF has been developed by K+P Transport Consultants, Tritel and MINT³. The FMF is used to determine the impact of hypothetical scenarios on future freight transport. A recent description can be found in Grispen (2011, pages 6 and 12).

On the basis of this freight model, it is possible to simulate future freight flows by mode (road, rail and inland waterways) and NST freight category. Simulations are made at the Flemish district level (arrondissementen). Flemish ports are included as separate zones. An adjusted 4-step model is applied:

- Flow generation: in this step, we determine the flows arriving in or departing from a particular zone within a particular timeframe. In the case of freight transport, this means that, for a given freight category k , we calculate the tonnage departing from (or arriving in) zone i (j) within a given period;
- Distribution of flows: the generation of flows serves as an input for this subsequent step. Now, the freight flows are determined between zones i and j ;
- Mode choice: here we determine which mode is used to transport tonnages from zones i to j ;
- Assignment: this step relates to route choice (after translation of tonnages into number of vehicles by means of a traffic conversion model).

Transport Logistic Nodes (distribution center for road transport) and inland terminals (for inland navigation) are also included in the model. In the case of road transport, the choice between direct

³ In 2011, a change occurred in the composition of the consortium of developers of the Freight Model: Tritel left the consortium, Significance joined and Protrans is the merger of ProTrans and K+P Transport Consultants.

transport and the use of a logistic node is modeled. A separate model is included to transform tonnages into number of vehicles.

It is important to note that, in the freight model, ongoing infrastructure projects (“lopente programma”) by the Flemish government are taken into account. In theory, forecasts are possible until 2050. Until now, forecasts have mainly been made until 2020.

Each scenario is composed of assumptions concerning economic growth (e.g. growth of GDP, growth of employment), infrastructural changes (e.g. introduction of a new lock for inland navigation). For each scenario, *tkm* and *vkm* are calculated. These indicators can be calculated at different geographical levels: at regional, Flemish level, or lower (e.g. Province of Antwerp, City of Antwerp).

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 Table 1⁴.

Table 1: Type of vehicles in FMF

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: VC/MINT

⁴ The tonnages in Table 1 refer to the maximum load of the vehicle, not to the average load.

The FMF is an aggregated and strategic model. Its purpose is not to evaluate a new location of a company. The FMF is not intended either to be used to assess individual projects (so-called MOBER's or "mobiliteitseffectenrapportages"). Calculations are first of all performed at the level of NUTS-3 zones (districts). Global evolutions are actually taken into account (e.g. increase of employment).

2.2 Role of the Research Centre on Commodity Flows

The role of the *Research Centre on Commodity Flows* in the period 2007-2011 was defined as the scientific follow-up (quality control) of the development of the FMF, giving suggestions for further improvement and assisting in carrying out calibration exercises and validation. The Research Centre also used the FMF in several applications, so as to be able to test and comment on the model in real-life situations.

In section 3 of this paper, an overview is given of the approach for assessing and further developing the FMF. Section 4 presents some applications that were made with the FMF. In section 5, conclusions are drawn for the future development of the FMF.

2.3 Freight modeling in Flanders

In Europe, freight transport models are developed at a regional, national and European level. In this section, an overview is given of models which are relevant for Flanders and which are used or in development in 2011 (section 2.3.1). Attention is given to a current trend in freight modeling (section 2.3.2) and some points of interest are formulated when dealing with freight transport models (section 2.3.3).

The description of the following freight transport models is a snap-shot of the situation in 2011, given the fact that each freight transport model is continuously in development.

2.3.1 Relevant other freight models for Flanders

The following other freight transport models are relevant for Flanders: LAMBIT, NODUS, The RuimteModel Vlaanderen, PLANET 2 and TRANS-TOOLS.

LAMBIT

Within the research group MOSI-T (VUB), a Location Analysis Model for Belgian Intermodal Terminals (LAMBIT) is being developed. LAMBIT is a geographic information system (GIS)-based location analysis model. LAMBIT allows defining market areas of the current intermodal terminals (ex-post analysis) and potential terminals (ex-ante analysis), for inland navigation as well as rail transport. The

focus of the research is on container transport. Based on a cost model, the total transport cost is calculated between the port of Antwerp and any Belgian municipality (being intermodal or unimodal). For each destination, the cheapest option can be defined. By using this methodology, it is possible to determine the market areas of terminals. Another possibility is to calculate the potential volume of container transport that can be shifted from pure road transport to intermodal transport. (Macharis, 2000; Macharis *et al.*, 2008a; Pekin *et al.*, 2007)

NODUS

In NODUS, origin-destination flows are simultaneously assigned to the mode of transport (road, rail and inland navigation) and the route, on the basis of minimizing the generalized cost of transport between origin and destination. A further distinction is made on the basis of type of vehicle (e.g. on the basis of loading capacity). In order to make the calculations, a virtual network is used whereby each link is assigned a cost function (each link represents a specific unimodal transport situation). As such, intermodal combinations are possible. Results are calibrated on the basis of observed flows on the main axes and the observed, aggregated modal shares (Beuthe *et al.*, 2001, Macharis *et al.*, 2008b)⁵.

The RuimteModel Vlaanderen

The RuimteModel Vlaanderen (VITO) is a hybrid cellular automata land use model featuring a built-in 4-stage multi-modal transportation model. The RuimteModel Vlaanderen represents processes operating at three hierarchically embedded geographical levels (Gobin *et al.*, 2009). At each level, a representation is chosen adapted to the precise needs of the problem studied and the available data in terms of the degree of sophistication and spatial resolution applied: the Global (one spatial entity: the Flanders and Brussels regions, modelled by means of a set of coupled scenario trends, representing population and some 5 economic sectors), the Regional (administrative entities: 23 districts, modeled by means of a gravity-based spatial interaction model, representing population and some 5 economic sectors, 10 nature categories and 5 agricultural classes) and the Local (a two-dimensional regular grid of some 13 million cellular units of 1 ha each, modeled by means of a cellular automata model, representing some 35 land use options).

The RuimteModel Vlaanderen is most useful for on the mid to long term horizon, meaning some 5 to 40 years into the future. It runs on a yearly time step and generates alongside the changing land use

⁵ A recent description can be found on <http://www.tmleuven.be/methode/goederenmodel/index.htm>.

and land coverage also a series of social, economic and environmental indicators, each of which becomes available in the course of the simulation as a time series of maps, both at the Regional and the Local level. (Gobin *et al.*, 2009, Maes *et al.*, 2009, Peymen *et al.* 2009)⁶.

PLANET 2

The Federal Planning Bureau has developed a model (PLANET) that describes the interaction between Economy and Transport (freight and passenger transport), with the help of 5 modules (MACRO, TRANSPORT, COST, POLICY en WELFARE). The TRANSPORT module starts from exogenous economic and demographic developments and is based on a four-stage model (road, rail, inland navigation, short sea shipping; NUTS-3). PLANET is being described as a projection model of freight and passenger transport on medium and long term, and is meant to be a support tool for the FOD Mobility and Transport⁷.

TRANS-TOOLS

Trans-Tools (Tools for Transport Forecasting And Scenario Testing) is a European transport model (passengers and freight), financed by IPTS (Institute for Prospective Technological Studies; Joint Research Center) and DG TREN/MOVE. The model is considered as the reference instrument for simulations at the European level. It should be noted that Trans-tools has received lot of criticism. From 2011 on, version 3 is being developed within the 7th European Framework. It is remarkable that the composition of the consortium is different from the consortium of versions 1 and 2, having an influence on the continuity of the development of Trans-Tools (e.g. results of simulations of version 3 can be different from previous versions). Trans-Tools is also confronted with data problems, being also the consequence of working at a higher geographic level. For the modeling of freight transport, NUTS-2 zones are used (provinces in Belgium) and the modes road, inland navigation, rail and sea transport are considered⁸.

2.3.2 Current trend in freight modeling

A current trend in freight modeling, is the combination of freight transport models. In the framework of various research projects, freight transport models are combined with other types of simulation models. In this way, the different models can strengthen each other. Some examples are:

⁶ An extended description can be found in VMM (2009), chapter 10.

⁷ An extended description can be found on <http://www.plan.be/Desc.php?lang=nl&TM=32&IS=57> and <http://www.plan.be/overview.php?lang=nl&TM=32&IS=70>.

⁸ For more information: see Ibanez (2011) and Nielsen (2011).

- A decision support system for intermodal transport policy: combination of LAMBIT, NODUS and SIMBA (discrete event simulation model for inland navigation), see: <http://www.belspo.be/belspo/fedra/proj.asp?l=nl&COD=SD/TM/08A>;
- LIMOBEL: combination of Planet 2, NODUS and E-Motion (energy consumption and emissions), see: <http://www.belspo.be/belspo/fedra/proj.asp?l=nl&COD=SD/TM/01A>;
- Preparatory research has been carried out in 2010 to combine the Strategic Freight Model Flanders, LAMBIT and The RuimteModel Vlaanderen.

2.3.3 Some points of interest

Some points of interest are formulated which are important for the development of freight transport models. These points are based on the conclusions made during the CTS seminar in Stockholm in 2011 “European and national freight models”⁹.

Freight transport models are fed with data (base dataset). On the basis of a base year, the features are determined of the transport system, after which simulations for the future can be made. Nevertheless, this is the weakness of all freight transport models in Europe. Usually, it takes a lot of time to construct a base dataset, having the consequence that the base dataset is outdated quite soon.

The following problems also occur when constructing a freight transport model:

- The collection of rail freight data is problematic in all countries (and especially after the liberalization of the sector), inclusive the determination of rail capacity on rail tracks;
- Air freight and pipeline transport are not included yet in all freight transport models;
- Freight transport models can't be used to make simulations about origin-destinations in case these are not included (or not yet existing) in the original base dataset;
- It is not evident to include the economy as an endogenous variable in freight transport models;
- An innovative data collection method is needed.

Chow *et al.* (2010) is a recent, international state-of-the-art report, containing the analysis of some freight transport models, the description of data needs and future needs of model developments. Complementary to the article is De Jong *et al.* (2004) with a focus on freight transport modeling in Europe.

⁹ See <http://www.kth.se/en/abe/centra/cts/seminarier/temadagar/temadagar2011/european-and-national-freight-demand-models-1.71991>)

3 Assessment and development

By using several analytical and supporting methods, the FMF has been tested and assessed. The several methods have led to the further improvement and development of the FMF. In the following sections, the focus is on calibration (section 3.1), validation (section 3.2) sensitivity analysis (section 3.3), the role of intermodal terminals (section 3.4) and an analysis of cost functions (section 3.5).

By using several methods to assess the FMF, it was possible to make suggestions to adjust this model. From a practical point of view, this means that the Research Centre could work with a version of the FMF. Research fellows of the Research Centre could therefore do tests themselves (being assisted by the VC and MINT). As such, this was a learning process for the people of the Research Centre. This was the best way to create interaction between the Research Centre and VC / MINT. By testing the Freight Model as a user, it was possible to detect inconsistencies and programming mistakes in the model. As soon as this happened, this has been reported to the VC /Mint and has been adjusted appropriately.

3.1 Calibration

Calibration is the process of modifying the input parameters until the output from the model more accurately reflects the observed set of data (Taylor, 2007). The process of calibration involves the adaptation of coefficients in the model which are needed to have a good match between the observed values in the base dataset and the simulated values of the base dataset. As such, only the values are used which were necessary for the development of the model. The analysis in this section is thus focused on the prediction of the base set, which in theory should be the same as the base set. In order to predict future freight flows, utility functions are used in the FMF. In this section, calibration means adapting the parameters in the utility function.

The FMF is a resource-intensive model in terms of the necessary input data. Imperfect data are an inevitable fact especially due to the nature (i.e. confidential data) and scarcity (i.e. absence of data collection mechanisms) of part of the data required. Additionally, its purpose is to serve as a predictive tool and therefore its validity needs to be established. Calibrating the model was therefore a necessary step before putting the model in practice. Such task however requires a deep understanding of the observed mechanisms of the transport system. Transport economic theory is hence of fundamental importance to the evaluation of data-driven output and vice versa data-driven output is fundamental for the confirmation or questioning of the theory. It is for this reason that the involvement of the Research Centre with its expertise in transport economics was requested.

In order to perform the calibration exercise, the Research Centre performed following steps. Please note that the VC and also MINT performed separate calibration exercises.

In step 1, the sum of tonnages for all modes and NST categories for 2004 observed and 2004 estimated were calculated and compared. All origins and destinations are taken into account. As such, two totals were compared.

In step 2, the sum per mode per NST-category for 2004 observed values and 2004 estimated values was analyzed. Additionally, the share of each NST-category per mode of the aforementioned sums for 2004 observed and 2004 estimated was calculated and compared. The target area was limited to Flanders given its significance in the majority of the research projects. Only values are taken into account in case origin or destination is within Flanders (NUTS-1). Specific criteria were included to assess the estimated values. The purpose of this step is to be able to select origin-destinations of which the estimated values are not acceptable. In particular, the following criteria were defined as necessary:

- Criterion 1: maximum 20% of absolute ton differences between observed and estimated value;
- Criterion 2: maximum 500 000 tonnes of difference between observed and estimated value;
- Criterion 3: maximum 5% modal share difference within an NST category.

Based on these criteria, it was possible to select NST-categories within a mode, for which the corresponding utility functions were consequently adapted. In theory, according to this methodology the process of calibration ends when all criteria are satisfied. However, modeling and practical limitations forced us to terminate the calibration even at a “non-optimal” level. Therefore, the calibration was terminated at the NUTS-1 level based on totals per NST category. Given time lack, it was not possible to perform a similar analysis at a more detailed level (more detailed zones, e.g. analysis per geographical area per mode per NST category)

The criteria combinations made ranged from most stringent to moderate approach 1 and moderate approach 2.

Most stringent approach

The stringent approach was defined as: if one of the three criteria is satisfied within a category, then further research is needed for this category. This approach led to the selection of 20 categories as

being suboptimal. It was however assessed that this approach was too stringent. Therefore, more moderate approaches were introduced.

Moderate approach 1

Moderate approach 1 was defined as:

- If Criteria 1 AND 2 are violated then further research is necessary.
- If Criterion 1 OR - 2 is violated then:
 - ⇒ if Criterion 3 is violated then further research is necessary
 - ⇒ if Criterion 3 is not violated the no further research is necessary

As a consequence, new simulations were made by changing parameters in the utility functions of the NST-categories. After changing the parameters and making new simulations, the criteria were tested again until the moment all criteria were fully satisfied.

Moderate approach 2

Moderate approach 2 was defined by adjusting the original criteria in the following way:

- Criterion 1: maximum 10% absolute ton differences;
- Criterion 2: maximum 500 000 tonnes;
- Criterion 3: maximum 5% modal share difference within an NST category.

The same procedure as described in Moderate approach 1 was applied. The results of the previous analysis were communicated towards the VC/ MINT. Appropriate measures have been taken to adjust the Freight Model.

3.2 Validation

Validation is the process that takes place after the calibration and means that a simulation model is confronted with empirical data which were not necessary for the development of the model. The results of the model are confronted with real values. Starting from the base data, either forecasting (*future real values*) or backcasting (*past real values*) could be part of the analysis.

It was however not possible to carry out this validation process due to a lack of empirical data. For the development of the FMF, the setup of the base data (2004) took a huge amount of time by VC / MINT leading to the observation that this analysis is out of the scope of the tasks for the Research

Centre. Anyhow, suggestions are made in section 5 to incorporate these activities in the future development of the FMF.

3.3 Sensitivity Analysis

The objective of the sensitivity analysis performed for the Strategic Freight Model Flanders was to examine how the variation of the model's output is attributed to the variation in terms of cost inputs of the model. The effects of such changes were measured in terms of ton kilometers and mode choice.

In the FMF, cost functions are included for the several modes. Cost functions are needed to determine the choice between road transport, inland navigation and rail transport. For each mode, for each NST category and for each type of vehicle, cost functions are composed of time costs, distance costs and costs of loading/unloading. The Research Centre focused the sensitivity analysis on these costs, based on the vehicle types as shown in Table 1.

The following steps are part of an iterative process. This means that the steps are carried out by the Research Centre and the corresponding results are presented to the VC / MINT. The VC / MINT have made the appropriate changes in the FMF (e.g. changing of some parameters) and this new version of the FMF was analyzed again by the Research Centre during the period 2007-2011.

Step 1: "Changing the costs"

Per mode, the costs are changed with +1%, +5%, +20%, +50%, -1%, -5%, -20%, -50%. This means that time costs, distance costs and costs of loading/unloading are changed simultaneously, one mode at a time. All other variables and parameters are kept constant. This leads to an output of the FMF; for this sensitivity analysis it was opted to work with tonkilometers and vehiclekilometers.

As a result, 3 x 8 scenarios are calculated, each leading to output in *tkm* and *vkkm*:

- ⇒ Scenario's 1a – 1h: "Road scenario" – with a-h representing abovementioned cost changes;
- ⇒ Scenario's 2a – 2h: "Rail scenario" – with a-h representing abovementioned cost changes;
- Scenario's 3a – 3h: "Inland navigation scenario" – with a-h representing abovementioned cost changes.

Step 2: "Analysis of the signs"

Each scenario has led to an output in *tkm*. From a theoretical point of view, one might expect the following relation:

- ⇒ In case a cost increase is introduced for one mode, one might expect a decrease in demand for this mode and an increase in demand for other modes.
- ⇒ In case a cost decrease is introduced for one mode, one might expect an increase in demand for this mode and a decrease in demand for other modes.

Starting from these expected relations, output per mode and per type of vehicle was analyzed. In case a sign was not expected, this was reported to the VC /MINT.

Three remarks should be formulated. Firstly, the FMF assumes a linear relation between costs and prices. The freight model is using costs as they are more easily available than prices. This assumption also implies that cost increases are fully incorporated in the prices.

Secondly, it might also occur that shifts are noted between vehicle types of one mode. For example, from heavy vehicles to light vehicles. As such, at first sight, one might see an unexpected sign, but could also be the consequence of a shift between type of vehicles.

Thirdly, *tkm* is reported on the basis of distance on the Flemish territory. Changing routes may have impacts on routes used outside Flanders and affecting also the distance on the Flemish territory.

Step 3: “Comparison with other elasticities”

The own price elasticity gives the percentage change in demand of a mode, in case the price of that mode is changing by 1%. The cross price elasticity gives the percentage change in demand of a mode, in case the price of another mode is changing by 1%. An overview of elasticities can be found in Pauwels (2007) and De Jong *et al.* (2010). Generally speaking, one can expect elasticities with values between -2 and 2. These values were used to assess the outcomes of the FMF.

In-between versions of the FMF showed sometimes values outside the range of -2 and 2. This has been reported to the VC / MINT and appropriate measures have been taken.

Step 4: “Analysis of cost changes > 1%”

In step 3, the effects of small cost changes have been analyzed. In this step 4, the focus lies on bigger percentage cost changes, +5%, +20%, +50%, -5%, -20% and -50%, with effects on demand for a mode expressed in *tkm*.

Two reasons can be mentioned to make an analysis on the basis of bigger cost changes:

- Testing whether the model is still giving results in case of big cost changes. It might happen that a model is crashing because of high input values;
- Testing whether the model is giving reasonable results.

Generally speaking, one might advise to use the model only in case of cost changes in the range between -20% and +20%. In this step, we tested also the scenario of -50% and +50%, but this test should be seen in the framework of the first reason mentioned above.

Following method has been used to assess the results:

In case of a cost increase of road transport:

- In case the cost of road transport is increasing by 1%, the demand for mode i will change by x%
- In case the cost of road transport is increasing by y%, the demand for mode I will change by z%
- We compare z%/y% with x%
- i = road, rail, inland navigation

On the basis of this method, we can see whether the reactions are becoming stronger or weaker, in case of different cost increases.

In case of a cost decrease of road transport:

- In case the cost of road transport is decreasing by 1%, the demand for mode i will change by x%
- In case the cost of road transport is decreasing by y%, the demand for mode I will change by z%
- We compare z%/y% with x%
- i = road, rail, inland navigation

On the basis of this method, we can see whether the reactions are becoming stronger or weaker, in case of a cost decrease.

A similar method is applicable to the analysis of inland navigation and rail transport. Please note that instead of z%/y% one might also consider $d\ln x/d\ln p = (\ln x_1 - \ln x_2)/(\ln p_1 - \ln p_2) = (\ln x_2 - \ln x_1)/(\ln p_2 - \ln p_1)$. In this formula

- x1 represents the original *tkm*;
- x2 represents the new, simulated *tkm*;
- p1 represents the original transport price;
- p2 represents the new transport price.

3.4 The role of intermodal terminals

In order to improve the working of the model, a qualitative analysis on intermodal terminals was performed by MINT. In order to prepare this analysis, the Research Centre has done a number of preparations and provided MINT with the contacts and meeting moments.

Within the framework of improving the modeling and understanding intermodal transport, some relevant parties were contacted by the Research Centre. The interviews were performed by MINT. The interviews focused on the use of container terminals in Flanders, the role they play in the Flemish network and the type of goods passing via these terminals.

Meetings were arranged with Euroports Containers Meerhout, Procter & Gamble, Nike and TCT (Willebroek).

Within the framework of other projects of the Department of Transport and Regional Economics, it was also possible to transfer information on intermodal terminals. This information is based on interviews by Department members.

3.5 Cost functions

Cost functions are an important part of the Flemish freight model. For each mode, functions are included about the calculation of costs to transport goods from point A to B. MINT produced in 2009 a technical note on the cost parameters. This document was screened by the Research Centre and was adjusted by MINT. Preliminary research has been set up to include quality aspects (such as value of time).

4 Applications

In section 3, the focus was on the methodological analysis of the freight model. The FMF was used within several projects, carried out by research fellows of the Research Centre, as described here. These applications have led to a further improvement of the FMF. First of all, each project requests a specific output, which was not always existing as output in the FMF. To that purpose, the FMF was extended by introducing new types of output. Second, by applying the FMF for a specific project, it was possible to detect minor software inaccuracies.

In this section, we present four applications:

- Section 4.1: The effect of land use;
- Section 4.2: Tactical study E313;
- Section 4.3: The effect of infrastructure change;
- Section 4.4: The effect of pricing.

The applications have been put in chronological order. This means that every application has led to improvements, which were of course included in the following research initiatives. This also means that the mentioned assumptions should be seen in the context of the existing version of the FMF when carrying out the application.

4.1 The effect of land use

At the request of the Flemish Government's Agency for the Economy (Agentschap Ondernemen), Arcadis and the University of Antwerp (Department of Transport and Regional Economics) have conducted a study into policymaking on the supply of waterside industrial land and water-based transshipment locations. Part of the study aimed at a quantitative and qualitative assessment, on the basis of the most likely scenarios of future developments in industrial and transshipment activity along Flanders' navigable waterways, with horizon 2020. The focus here is on the quantitative analysis, which was performed by the University of Antwerp.

The research question for this case is:

How can priority regions be selected for investment in waterside industrial land on the basis of a quantitative analysis?

On the basis of the results of this case, it is easier for policymakers to select regions for additional investment in landside industrial locations under financial constraints. The government wants to avoid that new waterside industrial estates are not occupied by activities using inland waterways.

For full results, we refer to Arcadis and University of Antwerp (2008a and 2008b) and Button and Reggiana (2011).

4.1.1 Methodology

The quantitative analysis involves the following steps:

- Simulation of inland navigation flows on the basis of scenarios;
- Survey-based determination of regional demand for waterside industrial sites;
- Prioritisation of regions for further investment in such sites.

The methodology applied is demand-oriented. The analysis starts from the existing pattern of demand and assumptions are made regarding future trends. The horizon is 2020 and the analysis is carried out at the Flemish NUTS-3 level (districts) of spatial aggregation.

To determine the need for additional waterside industrial space, we initially predict the tonnage that will be transported by inland navigation in 2020. For each district and goods category, an indicator is created expressing the need for land in 2004 and 2020. Some of the growth will be accommodated through land already available, with the rest requiring newly created space.

The indicator is set on the basis of regional transfer coefficients that represent the annual tonnage per m^2 to be transported to and from a given region. They are determined using internet surveys and personal interviews. The latter provide only information about waterside industrial sites; the sum of transfer and storage areas, and production. The data used is provided by the waterway administrators Waterwegen en Zeekanaal NV and nv De Scheepvaart.

The area indicator for 2004 is calculated per district and per NST-R freight category as:

$$area_{ri(2004)} = tonne_{ri(2004)} / k'_{ri(2004)}$$

where: $area_{ri}$ is m^2 needed to handle $tonne_{ri}$; $tonne_{ri}$ is the tonnage per district r per freight category i (incoming + outgoing flows); and k'_{ri} is the real relationship between $tonne_{ri}$ and $area_{ri}$, per freight category i , expressed in $tonne$ per m^2 . Important in the analysis is the determination of k'_{ri} . We use an average value for the relationship between tonnage and area estimated on the basis of internet surveys and personal interviews.

Next, an indicator for 2020 based on simulated tonnages generated through the FMF is estimated. Suppose that the surface area used in 2020 is identical to that in 2004, we can then calculate:

$$k^*_{ri(2020)} = tonne_{ri(2020)} / area_{ri(2004)}$$

We can also define the theoretical, optimal relationship between tonnage and area as k_{ci} : where k_{ci} is the theoretically optimal relationship between ton_{ri} and $area_{ri}$ at full capacity per freight category i . If, for example, k_{ri}^* equals six tonnes per m^2 and k_{ci} equals 11.5 tonnes per m^2 , then a surplus of available space and capacity is wasted.

If $k_{ri}^*(2020) > k_{ci}$, a capacity problem will present itself in 2020 in district r regarding freight category i . If $k_{ri}^*(2020) < k_{ci}$ then no capacity problem will present itself in r insofar as freight category i is concerned.

Future demand for a given area is:

$$(ton_{ri(2020)} / k'_{ri(2020)}) - area_{ri(2004)}$$

Three values for $k'_{ri(2020)}$ may be considered, based respectively on the current regional transfer coefficient ($k'_{ri(2004)}$), the economically optimal regional transfer coefficient, and the maximum regional transfer coefficient (which is not necessarily the economically most efficient one).

4.1.2 Results

Table 2 shows the values of the regional transfer coefficients. We differentiate between the various freight categories. On the basis of information about site areas and inland-waterways-related tonnage, the regional transfer coefficient is determined.

Table 2: Regional transfer coefficients in tonne per m^2 per year per freight category (NST-R) for waterside companies

NST-R	Regional transfer coefficient
0. Agricultural products and animals	2.99
1. Food	
2. Solid fuel	5.00
3. Petroleum products	7.38
4. Iron ore and scraps	7.33
5. Metallurgical products	
6. Minerals and building materials	
7. Fertilizers	1.58
8. Chemical products	
9. Diverse products	5.00
All observations	5.00

Source: Own composition

For the purpose of further calculations, the original regional transfer coefficient is multiplied by 1.5 and the original regional transfer coefficients are doubled. Using these values, we calculate the crucial turning points in demand for additional land. The values 1.5 and 2 express the potential increases in transfer given the available capacity and technological improvements. They are, however, not real values but are based on expert information and available foreign data regarding the relationship between site surface area and transfer. More efficient production or storage could, for example, result in a higher coefficient.

Table 3 shows the additional demand for land in 2020 on top of that in 2004 based on companies located in the proximity of water. If demand in 2020 exceeds the available land in 2004, the additional amounts are included in the table. On this basis, it is also possible to calculate the theoretical volume of surplus land.

The results are used to prioritize across regions with respect of their need for additional waterside industrial land. In other words, it may be used by a government to draw up a list of locations where there may be a case for investment in land availability. These absolute figures should be treated with some caution and should be interpreted as a broad indicator, rather than being read as exact figures.

The third column of Table 3 shows the overall results assuming a constant regional transfer coefficient per freight category. Each increase in the tonnage shipped by inland waterways leads to an increase in demand for space. The results shown in the fourth column are based on the assumption that reserve capacity is available, expressed as 1.5 times the original regional transfer coefficient and those in the fifth, if the regional transfer coefficient doubles.

Table 3 : Additional demand associated with the reference scenario

Groups	Name of district	Additional demand in ha in 2020		
		k' constant	k' x 1.5	k' x 2
Total		3,135	1,063	148
Great need	Antwerpen	2,144	756	119
	Gent	603	203	12
Moderate need	Sint-Niklaas	132	43	7
	Roeselare	71	25	3
	Kortrijk	40	9	2
	Brugge	31	10	1
	Hasselt	22		
	Tielt	18	6	1
Limited need	Turnhout	14		
	Mechelen	14	2	0.44
	Oostende	12	4	0.99
	Halle-Vilvoorde	10	1	
	Aalst	9	3	0.48
	Dendermonde	5	0.47	
	Oudenaarde	4	0.39	
	Leuven	2	0.47	0.00
	Tongeren	2		
	Maaseik	1	0.03	
	Eeklo	0.13		
	Veurne	0.00		
	Diksmuide			
	Ieper			

Source: Own composition

From the analysis, it is possible to draw up a priority list of NUTS-3 regions associated with each scenario. The observations are put into three groups: great, moderate and limited need for additional waterside industrial land. The following groups are distinguished in the reference scenario of an unchanged policy:

Great need	Antwerp and Ghent;
Moderate need	Sint-Niklaas, Roeselare, Kortrijk, Bruges, Hasselt and Tielt;
Limited need	Oudenaarde, Louvain, Tongeren, Maaseik, Eeklo, Veurne, Diksmuide and Ypres.

Policy on waterside industrial land may be assumed to be directed primarily at accommodating high-priority regions. It should be noted, in this context, that port-related needs are taken into account. Hence, the figures for Antwerp and Ghent also reflect the needs of neighboring industrial zones. Therefore, the additional space needs not necessarily be located in the port itself. It may also be advisable in other instances to seek additional land in neighboring NUTS-3 regions rather than in the NUTS-3 region under study (given a lack of space in the latter).

A dynamic policy (single increase of the vehicle cost by 20 percent, followed by a yearly growth of 0.1 percent) results in a higher demand for inland navigation and thus a higher demand for waterside industrial land. This is also the case if the cost of inland navigation declines. However, we find small differences between the rankings under the different scenarios. This indicates a possible slowness. In other words, it would require quite significant policy changes for the various scenarios to impact on the rankings.

4.1.3 Policy conclusions

Governments often need to assess how demand for waterside land may change in the future. Some of the projected growth in inland navigation in Flanders may be accommodated by existing industrial land, but the remainder will require additional space. In this context, it is useful that a priority list for investment in such locations should be drawn up. Our analysis offers one way of doing this and provides some quantitative findings.

The following conclusion can be formulated on the basis of this case: The government should invest in waterside industrial sites in the regions Antwerp and Ghent to stimulate IWW transport.

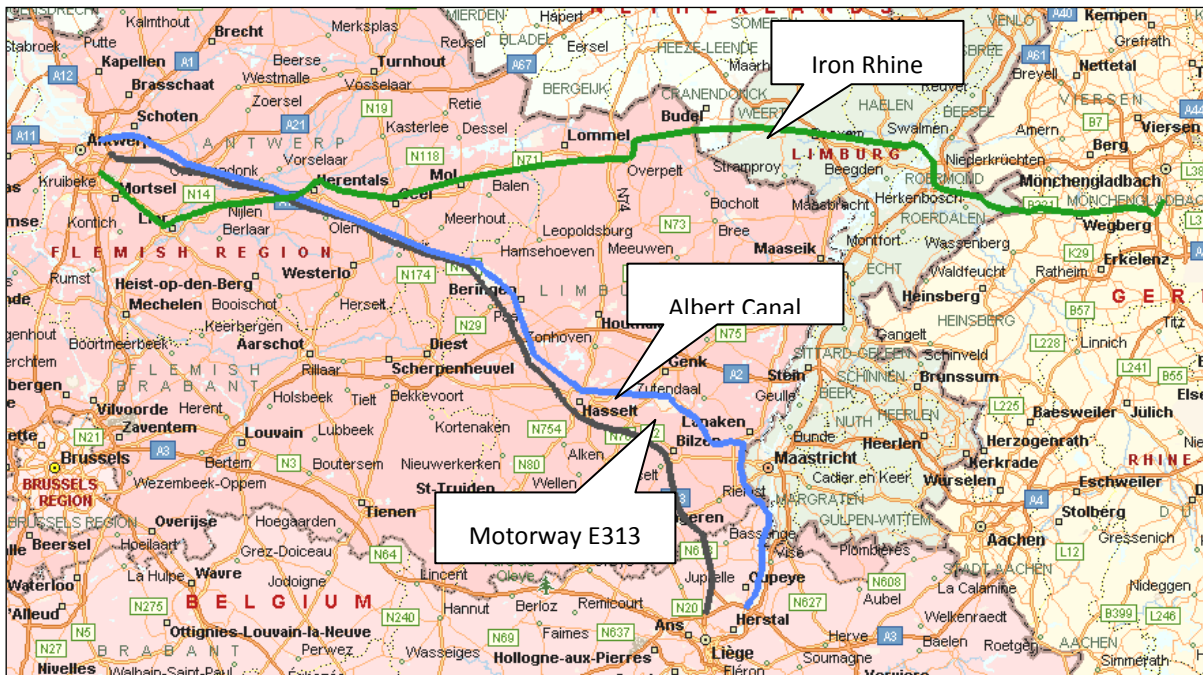
4.2 Tactical study E313 – calculating future scenarios for freight transport

At the request of the VC, a study on the E313 motorway was carried out. In this section, we present the main results. For full results of this project, we refer to Acosta *et al.* (2009a, 2009b).

4.2.1 Rationale and setting

As far as congestion is concerned, sea ports are often shown to be worst hit on the land side. This observation is also true for Flanders. In this paper, we analyse the situation for the E313 motorway, which is approximately 120 kilometres long. It connects Antwerp to Liège and is a link to the Ruhr area in Germany, as can be seen in Figure 1. For most of its length, it has two lanes in each direction.

Figure 1 : Motorway E313 (grey), Iron Rhine (green) and Albert Canal (blue)



Map source: Microsoft MapPoint 2009

The Port of Antwerp, the second largest port in Europe for international freight shipping, is one of the main generators of heavy goods vehicle traffic for the E313 route. Data for recent years shows that around 40% of all goods flows of the Port of Antwerp are transported to/from the port by road.

The motorway features particular competition from both rail and inland waterways, especially in dealing with port-bound traffic. As to waterways, the Albert Canal, which runs mainly in parallel with the motorway, is currently being subject to capacity expansion through the extension and elevation of a number of bridges that cross the canal. From the rail side, the Iron Rhine is a potential competitor of the E313 motorway. It is the historic railway line, started up in 1879, that runs from Antwerp to the German Ruhr area. Since 1991, this track is no longer used for international transport. Nowadays, the so-called Montzen route is used, which makes a detour over Liège. The Belgian Government has stated its intention to resume and intensify the use of the Iron Rhine railway line. Restoration, alteration and modernisation (referred to as “reactivation”) of the Iron Rhine route will therefore be required. Both Iron Rhine and Albert canal are part of the TEN-T network. The Iron Rhine falls within rail axis nr.24 (Lyon/Genova-Basel-Duisburg-Rotterdam/Antwerp), whereas the Albert Canal is part of axis nr.18 (Rhine/Meuse-Main-Danube).

Capacity optimization seems to impose itself, in view of the frequent occurrence of congestion and the many accidents featuring the motorway. The severity of the problem shows up also in a survey

held among Flemish road transport companies (Gevaers, *et al.*, 2009). On the other hand, a number of more general capacity optimization measures are being put in place by the European Commission but more importantly also by the Flemish government. The latter also deploys a mode shift strategy, with the aim of increasing the chances of both inland navigation and rail transport.

The study focuses on measuring the effectiveness of policy instruments and their combinations on E313 traffic. Various kinds of instruments are taken into account in the model scenarios. As a key instrument, the impact of road pricing is considered. Road pricing could either be deployed on motorways only or on all roads.

4.2.2 Research question and methodology

The situation described in Section 1 shows that capacity optimization is feasible, especially taking into account that mode choice alternatives to road transport are not yet fully exploited for the hinterland traffic of the Port of Antwerp. The main research question is therefore what combinations of measures provide sufficient results in alleviating congestion problems on port hinterland connections.

In order to outline possible future developments, first, a qualitative impact analysis was performed of port traffic evolutions, Albert canal expansion, short sea shipping evolutions, European policy developments, instruments developed within Flanders Logistics, Flanders Port Area and Flanders Inland Shipping Network, the possible re-introduction of the Iron Rhine, road infrastructure bottlenecks, and other important influencing factors on the E313. Those are described in detail in Section 3. Expanding road infrastructure over part or all of the motorway length was not considered to be a feasible solution at reasonable notice.

Based on the findings from the impact analysis, a link was made between the selected influencing factors and scenarios in the FMF. Several scenarios were built to construct a min-max range that describes assumptions on possible developments, which are dealing with the economy, policy, population and household consumption, imports and exports, and inland ports.

Modeling a reference scenario and 12 alternative scenarios for the year 2020 was done with the FMF. A three-level approach was adopted to interpret the simulation results. At the first level, total tonnages were calculated and figures were evaluated for every scenario. At the second level, route change investigation was done by interpreting a difference plot. At the third level, the mode shift was investigated.

4.2.3 Scenarios

A number of purpose-made scenarios were constructed (see Table 4). The scenarios are based on possible developments in the economy, as well as on possible policy that could be introduced by the government. Each scenario is a combination of several assumptions: economic, policy-related, linked to population and household consumption, dealing with import and export, and with inland navigation and ports. Underlying assumptions are explained in the next section.

Table 4: 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: Own composition

Economic, import and export assumptions

In *European Energy and Transport Trends to 2030 – update 2005* (European Commission, 2006b), a yearly economic growth of 2% until 2020 in Belgium is reported. This economic growth represents the yearly evolution of the Gross Domestic Product (GDP) in real terms, adjusted for inflation. This leads to 3 economic assumptions in this research project:

- Economic assumption 1: low growth (growth GDP – 0.5% = 1.5%)
- Economic assumption 2: normal growth (growth GDP = 2%)
- Economic assumption 3: high growth (growth GDP + 0.5% = 2.5%)

For foreign zones, the evolution of GDP is used as a proxy for the magnitude of freight flows between Flanders and those zones. Reference is also made to the forecasting report of the European Commission (2006b).

The growth of the import and export flows in value also serves as an explaining variable in the freight model. Both import and export flows follow the economic assumptions described above. Based on Federaal Planbureau (2008), it is assumed that the import and export flows will grow by 4.3% yearly when we have a normal growth in the economic assumptions, 3.8% if economic assumptions indicate a low growth, and 4.8% in case of high growth.

Policy assumptions

A distinction is made between a continuation of the current policy, a moderate transport policy, and a policy where the external costs of all transport modes are internalized.

Continuation of the current policy

In the assumption of continuation of the current policy, a growth of 0.1% per year of the costs of road and rail transport is assumed. A growth of the costs of road transport is considered probable given the far advanced deregulation of the road freight transport sector, where the largest cost advantages from deregulation have already been gained. For rail freight transport, the persistent dominance of national railway companies is assumed. A deregulation leads to a reduction of national subsidies and will cause an upward 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 as 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, which are much easier to obtain, are sufficient.

Moderate transport policy

The moderate transport policy differs from the continuation of the current policy in the assumptions made for the evolution of the costs for road and rail.

It is assumed that road pricing is introduced on the highways in the Benelux. The amount is set to be € 0.15 per kilometre and it will replace the traffic tax and the Euro-vignette. On the non-highways, this value is set to be € 0 per kilometre. For rail, it is assumed that a higher user fee will be introduced: in total € 3.30 per train-km).

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

Internalizing external costs of all modes starts with the assumptions from the scenarios on continuation of current policy and of moderate transport policy. It is now assumed that the internalization of external costs will apply to all ground transport modes.

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

- Road: € 0.075 per *tkm*
- Rail: € 0.005 per *tkm*
- Inland waterways: € 0.005 per *tkm*

Specific assumptions for inland navigation

In order to simulate cost advantages for inland waterway transport, specific assumptions were introduced.

- Continuation of current policy;
- Extra measure for 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.

Port assumptions

Scenarios 1-8 and the reference scenario comprise a basic growth path for the port of Antwerp which is based on the different economic assumptions. In scenarios 9-12 (see Table 4), explicit assumptions about the port of Antwerp are taken into account.

Additionally, in scenarios 9-12 some specific growth patterns are considered to simulate a weakening or strengthening of the competitive position of the port of Antwerp:

- In case of a stronger competitive position, it is assumed that the incoming and outgoing flows in tonnage for the port of Antwerp are 1.5 the initially estimated values;
- In case of a weaker competitive position, it is assumed that the incoming and outgoing flows in tonnage for the port of Antwerp are half the initially estimated values.

Scenarios 9-12 therefore allow for changes in port competition within the freight model.

4.2.4 Simulation results

A three-level approach has been adopted to interpret the simulations results. The full simulation results themselves are available in the report by Acosta *et al.* (2009a and 2009b).

Three types of output were produced:

- Total tonnages and growth figures for every scenario; or some specific points on the E313 motorway the tonnages (and hence vehicles) passing by are analysed;
- Evaluation of route changes based on difference plots;
- Mode shift analysis.

In all simulation results, the base year is 2004, while tonnages in the scenarios refer to 2020. Results of the first type of output refer to specific locations on the E313, as illustrated in Figure 2. In particular, locations 1 and 2 are close to Antwerp and are selected to illustrate the direct effect of the port of Antwerp. Locations 3 and 4 are selected in order to give a view on the tonnages behind the split between the E313 and E34. Finally, locations 5 and 6 are important because they are located in the vicinity of the intersection Lummen (E313 and E314).

Figure 2: Measurement locations on the E313/A13 motorway



Map source: Microsoft MapPoint 2009

The second type of output are route changes using a difference plot, an illustration tool of the Cube software. The purpose of this application is to illustrate the different scenarios in both colour and thickness. Hence, the scenarios for which this analysis was deemed necessary are benchmarked with the reference scenario, showing whether an increase or decrease in tonnages took place.

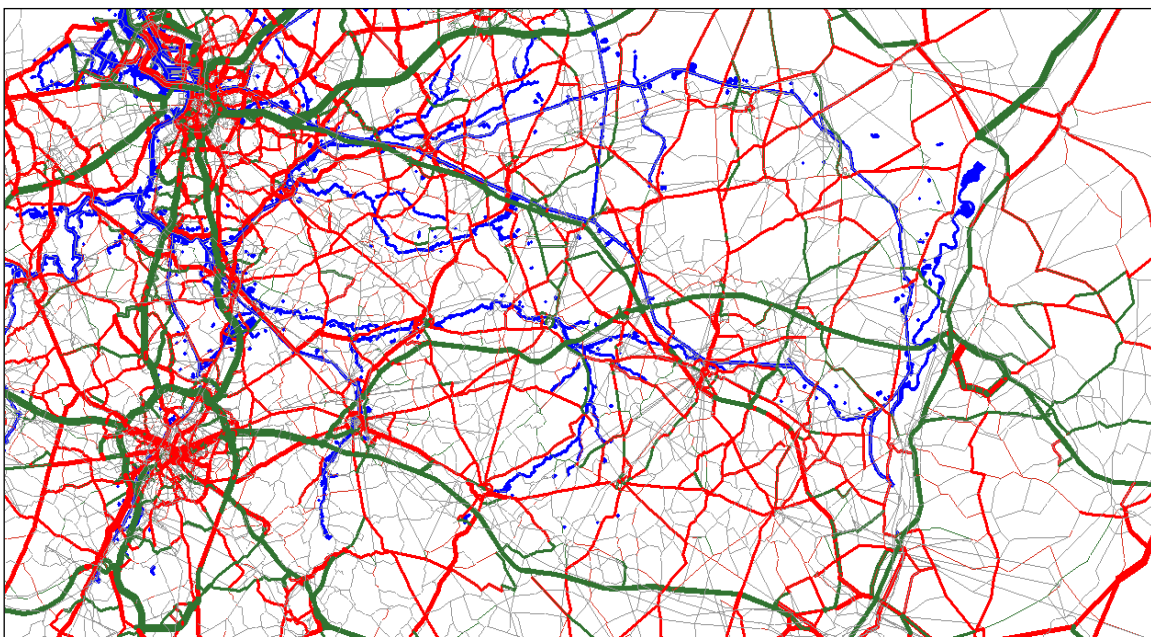
In particular, what is shown by the different colours could be summarized as follows:

- Red lines show an increase of more than one hundred tonnes;
- Green lines show a decrease of more than one hundred tonnes;
- 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.

An example of a difference plot output is presented in Figure 3.

Figure 3: Scenario 4 versus reference scenario



Source: Own composition based on Strategic Freight model Flanders

The third type of output is a mode shift change. Four regions were selected to analyze the mode shift effects of the scenarios: the port of Antwerp, district of Antwerp (excl. Port of Antwerp), the Turnhout region and the Hasselt region. The E313 passes through all the aforementioned regions.

For each region, the total incoming and outgoing flows in tonnage were calculated for road, rail and inland waterways. This enabled the calculation of the mode split for the base year 2004, the reference scenario and the specific scenarios for the year 2020.

Based on the three-level approach that was adopted to interpret the simulation results, a list of observations was made.

At a general level we found that:

- The results of the simulations show that combinations of measures with similar consequences have a bigger effect. Therefore, for practical implementation, a combination of measures is more advisable.
- A specific scenario may have different, even adverse effects on the traffic volumes in different points and directions of the road network.

With regard to evolutions of port traffic the major conclusion is that :

- Scenarios with port growth variations clearly show the impacts of port turnover dynamics on the traffic on the locations at the E313 motorway. 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 location, but in the direction away from Antwerp).

For inland navigation the following findings can be highlighted:

- In general, scenarios introducing the extra measure for inland navigation lead to an increase of the share of inland waterways with maximum 4% in the port of Antwerp. When internalizing the external costs of all modes, the increase is higher, up to 8%.
- The shift of road transport mainly moves towards inland navigation. For instance, concerning incoming flows to the port of Antwerp, the mode share for inland waterways goes from 40% to 48%.

Pricing policies have the following consequences

- The introduction of a moderate transport policy leads to a decrease of the traffic on the E313, but leads to an increase at the lower network. In practice, it means that route diversion occurs when a moderate policy in terms of kilometre cost charging on the highways is being enforced.
- In the case of charging the entire network with a kilometre cost variable equal to €0.15 together, the results differ substantially, showing that the decrease in tonnage becomes more widespread in the network.
- The introduction of the internalization of external costs policy for all modes creates the same network pattern but with the effects being more pronounced than the scenarios of moderate policy.
- The introduction of the internalization of external costs leads to a significant change in the mode split between road, rail and inland navigation.

Changes in economic and transport growth have the following major impacts:

- The result of low-growth assumptions on the goods flows on the E313 motorway is that, as expected, the volumes of the goods flows and also the annual growth decreases in all the locations on the motorway.
- The model captures the increase (decrease) in economic growth and international trade and links it to the higher (lower) growth of goods flows on the E313 motorway.

4.2.5 Conclusions

The case of the E313 motorway in Flanders illustrates that capacity optimisation can be a feasible option, taking into account the available alternatives to road transport that are not yet fully exploited for the hinterland traffic of the Port of Antwerp.

There is a set of factors including port traffic volumes, trends in the economy, available transport alternatives and legislation that influence goods flows by road in port hinterland connections. The FMF allows capturing those factors and link them to goods flows on the road network.

Results show that the introduction of different policy measures leads to significant effects in mode and route choice in port hinterland connections. For practical implementation, a combination of those measures is more advisable.

The methodology and main results of this study can be generalized so that they are applicable not only to the Flemish context, but under similar circumstances also to other port hinterland contexts, featuring strong road use and availability of rail and/or inland waterway alternatives. In that sense, the scenario runs and their results are of high relevance to policymakers in charge of alleviating port hinterland congestion problems.

4.3 The effect of infrastructure change

The case of infrastructure effects is part of a study carried out by the University of Antwerp and Arcadis, at the request of the Flemish waterway administrator NV De Scheepvaart. A Social Cost Benefit Analysis (SCBA) has set up for the replacement of three 600-tonne locks by one or two locks of minimum 1350 tonnes and the upgrading of the canal's capacity. This case focuses mainly on the freight transport economic feasibility study of the University of Antwerp.

Due to the dimensions of the existing locks ("Blauwe Kei", lock A in Figure 4), access to the waterway on the canal from Dessel to Bocholt (Flanders) is limited to small vessels of 600/700 tonnes. The waterway Dessel-Bocholt (D-B) is officially characterized as a class II waterway (600 tonnes load capacity). Nevertheless, the waterway D-B is deep enough to accommodate vessels up to 1,350

tonnes. D-B is among others connecting the Zuid-Willemsvaart (Z-W), the Canal to Beverlo (K-B) and the Canal Dessel-Kwaadmechelen (D-K). As such, a connection to the Netherlands and the Albert Canal is available (see Figure 4). The companies located at the D-B, Z-W and K-B can also be reached via the locks located in Bocholt from the North (direction The Netherlands, lock B in Figure 3) and from the south (Maastricht, lock C in Figure 4). The locks located at Maastricht are large enough to accommodate larger vessels up to 1,350 tonnes. In practice some of these larger vessels are allowed to sail on the canals if they are not loaded with more than 1,100 tonnes. This means that vessels with a load factor of 1,100 tonnes can reach the D-B via Maastricht but can't use the locks Blauwe Kei. For flows coming/going to Antwerp this results in a detour.

Figure 4: Accessibility of the waterways by vessel class



	Waterways	Class	Vessel capacity		Locks	Class	Vessel capacity
1	Dessel-Bocholt	II	1,350 tonnes	A	Locks Blauwe Kei	II	600/700 tonnes
2	Zuid-Willemsvaart	II	1,100 tonnes	B	Bocholt	II	600/700 tonnes
3	Canal to Beverlo	II	600 tonnes	C	Maastricht	IV	1,350 tonnes

Source: Promotie Binnenvaart Vlaanderen

The research question for this case is:

What is the effect on tonne-kilometre of freight transport in Flanders per mode when three existing 600-tonne locks (“Blauwe Kei”) are replaced by one lock of minimum 1350 tonnes and the corresponding canal’s capacity has been adjusted.

For full results, we refer to Beelen *et al.* (2009) and Arcadis and University of Antwerp (2009).

4.3.1 Methodology

This case was addressed by the use of the appropriately adjusted FMF and a set of scenarios. The scenarios used within the FMF are combinations of several assumptions: economic, import and export, policy, population, household consumption, and inland navigation. They are described briefly in Table 5.

For the purpose of this case, three scenarios were selected: a reference scenario and two alternative scenarios. According to Table 6, the reference scenario reflects the situation in 2020 without any capacity changes. Scenario 1 corresponds to the alternative of one lock, including an upgrading of the corresponding waterway. Vessels of 1,100 tonnes average load can now also use these locks instead of the Bosscherveld lock. Scenario 2 builds on “scenario 1” with the addition of an extra upgrading of the corresponding waterway (until Bree). Vessels of 1700 tonnes average load can now sail on this part of the canal.

Table 5: Scenario assumptions

Assumptions	Description	Quantification
Economic	Economic Growth (evolution of GDP in real terms adjusted for inflation)	Belgium: 2% yearly and Other countries: range between 1.4% and 3.0% yearly
Import & Export	Import and export flows growth expressed in value	4.3% yearly
Policy	Internalizing external costs of all modes (road, rail and inland navigation)	Road: (0.1% yearly cost growth) +(0.15 €/km on highways) +(0.075 €/tonkm external cost)
		Rail: (0.1% yearly cost growth) +(0.002929 €/tonkm)+(0.005 €/tonkm external cost)
		Inland waterways: (0.005 euro per tonkm external cost)
Inland Navigation	Yearly cost reduction of inland navigation cost	-2% yearly
Population & household consumption	Growth of population in Belgium & of household consumption	0.2% & 1.7% respectively

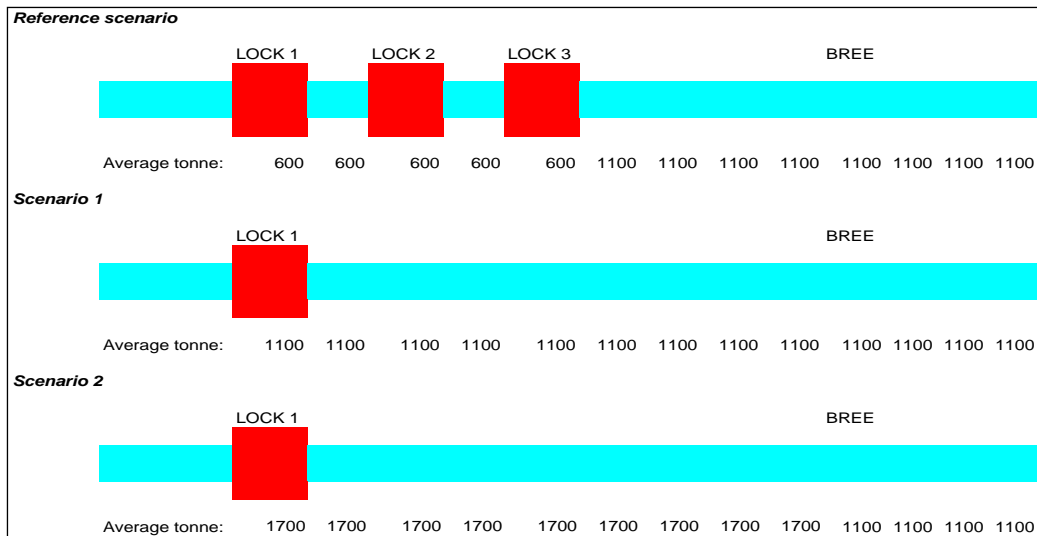
Source: Own composition

Table 6: The effect of infrastructure changes: scenarios

Scenarios	Locks	Capacity Locks	Capacity IWW	Assumptions		
		(Ton)	(Average Ton)	Economic Growth	Policy	Inland Navigation
Reference scenario	3	No change	1,1	Normal	Internalizing external costs	Extra measure
Scenario 1	1	Change	1,1	Normal	Internalizing external costs	Extra measure
Scenario 2	1	Change	1,7	Normal	Internalizing external costs	Extra measure
			(until Bree)			

Source: Own composition

Figure 5: The effect of infrastructure changes: graphical presentation of the scenarios



Source: Own composition

4.3.2 Results

An overview of the results in tonne-kilometre performed on the Flemish infrastructure is given in Tables 7 and 8.

From Tables 7 and 8 one can conclude that only minor differences exist between the scenarios. However, one should take into consideration that Tables 7 and 8 are based on the cargo flows on the total Flemish infrastructure. For example, in Table 7, an absolute difference of 19,636,470 *tkm* has been reported. This tonnage represents a growth of 0.21% in comparison with the reference scenario. As such, it can be derived that the introduction of a new lock leads to an extra growth of the passage through the new lock of 17.6%.¹⁰

From the calculations made in vehicle-kilometer (*vkm*)¹¹ it is observed that the number of *vkm* has also decreased as a result of the change of the lock Blauwe Kei. The main reason for this is the rerouting of the vessels and introduction of vessels with a higher capacity, both leading to less kilometres performed and a lower number of vessels used and hence less *vkm*.

Table 7: FMF output in *tkm* on the Flemish infrastructure

¹⁰ In 2007, an average performed distance of 66.89 km per trip of inland navigation on the Belgian infrastructure can be deducted (FOD Economie, 2010). This leads to an estimated extra volume of 293,577 tonnes. According to the Flemish administrator, a total of 1,288,678 tonnes passes through locks Blauwe Kei in 2007. Assuming an annual growth of 2% in inland navigation between 2007 and 2020, this corresponds to 1,667,042 tonnes in 2020 or 17.6% (1,667,042/293,577).

¹¹ The output in *vkm* can be found in Beelen *et al.* (2009).

Mode		Reference Scenario	Scenario 1	Scenario 2
		<i>Tkm</i>	<i>Tkm</i>	<i>Tkm</i>
Road	Total	30,051,439,207	30,034,977,221	30,034,975,881
	Absolute change		-16,461,986	-16,463,326
	Change in %		-0.05	-0.05
Rail	Total	5,121,916,417	5,121,381,448	5,121,381,448
	Absolute change		-534,969	-534,969
	Change in %		-0.01	-0.01
Inland Navigation	Total	9,313,868,914	9,333,315,424	9,333,505,384

Source: Own composition based on the FMF

Table 8: Output mode choice (based on *tkm* on Flemish infrastructure)

Mode split	Reference Scenario	Scenario 1	Scenario 2
Road	67.55	67.51	67.51
Rail	11.51	11.51	11.51
Inland navigation	20.94	20.98	20.98
Total	100.00	100.00	100.00

Source: Own composition based on the FMF

4.3.3 Policy conclusions

This case serves as an example of how input can be delivered to a social cost benefit analysis (CBA) in which the quantification of freight transport effects is a part. As such, the regional and economic characteristics present in the specific cases, play a decisive role in the final outcome of a CBA. Replacing a lock leads in this case to lower costs and a mode shift¹². Lower transport costs can be the result of using larger vessels, but can also be the effect of rerouting the vessels.

¹² In the full project, the establishment of new companies as a result of the new lock has also been investigated.

This case leads to the following conclusions:

- Increasing capacity of waterways leads to a higher use of IWW
- (Derived) Conclusion 5: Using innovative systems in inland navigation will lead to a higher use of IWW

4.4 The effect of pricing

The case of the pricing effect has been dealt within the broader aim of performing a sensitivity analysis of the FMF by the University of Antwerp.

In the context of future road pricing and/or internalization of external costs in Flanders, it is good to acquire an understanding of the reaction patterns of the several modes. Important remark here is that the exercise in this case applies to the full Flemish network, whereas road pricing refers to selected transport links.

The research question for this case is:

What is the effect on tonkilometer of freight transport in Flanders per mode when the price of a mode is changing?

4.4.1 Methodology

The results presented in this paper use elasticities. An elasticity in this case is defined as follows: *When the cost of mode i increases with 1%, what is the percentual change in demand of mode j ?* Mode i refers to road, rail or inland navigation (freight transport).

In the step “mode choice” of the 4-step model in the FMF, the determination of the mode used to transport tonnages is based on a monetary value. This monetary value is the sum of the kilometer cost, the hourly cost and the costs of loading and unloading between zones i and j . Increasing these costs with 1% will determine the elasticity.

Tonne-kilometre was used as output for this case, in which the distance is based on the actual distance performed on the Flemish infrastructure. The distance on the non-Flemish infrastructure is not taken into account.

Own-price elasticities as well as cross-price elasticities have been calculated for the three modes. A linear relation has been assumed between costs and prices. In the analysis, the effect of revenue recycling (what has been done with the revenues) is not taken into account.

4.4.2 Results

In general, price elasticities in Flanders are low, implying inelastic demand. Increasing the monetary cost of road transport by 1% in Flanders, will lead to an increase of the use of IWW by 0.19% (expressed in tonne-kilometer on the Flemish infrastructure) and will lead to an increase of the use of rail transport by 0.38%.¹³ In Table 9 the results of this exercise are presented.

Table 9: Price elasticities – effect on tonne-kilometre in Flanders

	<i>Road</i>	<i>Rail</i>	<i>IWW</i>
<i>Road</i>	-0.12	0.38	0.19
<i>Rail</i>	0.06	-0.83	0.06
<i>IWW</i>	0.09	0.19	-0.34

Source: Own calculations based on the Strategic Freight Model Flanders

The own-price elasticity of IWW is -0.34, which represents the corresponding decrease in volume of IWW when the price of IWW goes up with 1%.

4.4.3 Policy conclusions

Road pricing and/or internalization of external effects in Flanders will lead to a more correct pricing system (variabilisation of costs). Results of this case give a framework of the reaction patterns on the Flemish infrastructure. Future internalization of external costs and/or road pricing should today be an incentive for those who demand and supply freight transport. This leads to the following conclusions:

- Future road pricing and/or internalization of external effects will lead to a better capacity use of transport (higher load factors) and shifts to inland navigation.
- Suppliers of transport in inland navigation will have an extra incentive to pursue innovation in the sector (other types of vessels).

¹³ A bigger percentage change doesn't necessarily lead to a bigger absolute increase. This depends on the volume basis.

5 Conclusions

During the research period 2007-2011, an intense cooperation between the Research Centre, VC, MINT en K+P Transport consultants, has led to the possibility to assess, develop and apply the FMF. On the basis of the research, it is possible to make some conclusions about future approaches. Some of the conclusions and approaches have already been implemented in 2011-2012.

A distinction has been made between two types of conclusions: from a modeling point of view (“how can the theoretical framework be improved?”) and from the point of view of user-friendliness (“how can a user of the Strategic Freight Model Flanders work in an efficient way with the Strategic Freight Model Flanders?”).

5.1 Conclusions from a modeling point of view

Several conclusions can be drawn with respect to the underlying modeling of the Strategic Freight Model Flanders.

5.1.1 Price versus cost

A typical discussion in transport economics and modeling of freight flows, is the use of costs versus prices.

When moving goods from A to B, one can make a distinction between using costs and prices in transport modeling:

- The cost of transport to move goods from A to B starts from the assumption that the decision taker¹⁴ is owning the modes of transport, and the actual out of pocket costs of this mode are taken into account;
- The price of transport to move goods from A to B starts from the assumption that the decision taker is not owning the modes of transport. The amount of money that has to be paid for this service is the result of the market mechanism (demand and supply). In theory, this price can be lower and higher than the cost.

In order to model the choice between modes (road, rail, inland waterways), one needs a comparison of the respective costs/prices on which the decision maker is grounding the choice. In some cases, the decision maker is executing transport on own account. For this situation, one can consider the cost of transport. In other cases, when the decision maker should base its decision on the market conditions of providers of transport, the decision will be based on prices.

¹⁴ The decision taker is the person who takes the decision about which mode will be used (in this case: road, rail or inland navigation).

The FMF is using the cost of transport. This is a typical way of transport modeling, because information on prices is difficult to get. The FMF starts from the assumption of a linear relation between costs and prices. This means that cost increases are fully incorporated in the prices.

Advise: One might consider to carry out further research on the relation between costs and prices of transport in Flanders.

5.1.2 Validation

Validation is the process that takes place after the calibration (see section 3.1) and means that a simulation model is confronted with empirical data which were not necessary for the development of the model. The results of the model are confronted with real values. Starting from the base data, either forecasting (*future real values*) or backcasting (*past real values*) could be part of the analysis.

It was however not possible to carry out this validation process during the research period 2007-2011 due to a lack of empirical data. For the development of the FMF, the setup of the base data (2004) took a huge amount of time by VC / MINT leading to the observation that this analysis is out of the scope of the tasks for the Research Centre.

Advise: One might consider to perform a validation test on the FMF, once the base year (2004) will be changed to a more recent year. By using the old base year, a forecast can be made to simulate the new base year.

5.1.3 Effects of congestion

Congestion problems play a role in the mode choice process. Increased travel time leads to an increased cost/price of transport, and might lead to the choice of an alternative mode. This capacity problem is not only the case for road transport, but should also be considered for inland navigation and rail transport. In case of inland navigation, locks can be considered bottlenecks and could lead to congestion. In case of rail transport, some capacity issues might occur (e.g. hinterland rail connection of the port of Antwerp) or assignment issues might occur (e.g. interaction freight and passenger transport).

As a consequence, this topic is also related to the issue of time of the day modeling.

Advise: One might consider to carry out further research on the effects of congestion on mode choice, not only for road transport, but also for inland navigation and rail transport.

Remark: In the period 2011-2012, some initiatives have already been taken by VC and MINT in this respect, especially on the topic of time of the day modeling (road transport).

5.1.4 Inclusion of qualitative variables

The Strategic Freight Model Flanders is based on out of pocket costs as a quantitative decision variable. In some cases, decisions are not only taken on the basis of the out of pocket cost, but also other qualitative variables might be taken into account. Examples of qualitative variables are: value of time, reliability, flexibility, frequency and safety. For a recent overview, see Grosso (2011).

Advise: One might consider to carry out further research on implementing qualitative variables in the FMF.

5.1.5 Port competition and port zones

Port competition has a direct effect on the transport generating effect of ports. For example, freight flows might be shifted from one port to another affecting the respective hinterland. Another example, ports have a different growth pattern compared to regular NUTS3-regions.

As such, it is important that port zones are included in an explicit way in the FMF. During the period 2007-2011, several actions have been taken by the VC and MINT. First of all, the port regions Antwerp, Ghent and Zeebruges are included. Specific attention has been put on the port of Antwerp. In the framework of the Masterplan 2020, the base data has been adjusted in cooperation with the port of Antwerp. To make simulations for a future year, the ongoing infrastructure projects are taken into account. This involves new or adjusted infrastructure and specific employment effects.

Advise: It is important that the Flemish ports are included in the Freight Model Flanders as realistically as possible. This involves the cooperation of the Flemish ports in the further development of the FMF.

5.1.6 Container data

The Strategic Freight Model Flanders is based on freight flows expressed in NST-categories. The problem with this approach is that the modeling of container flows might raise questions. When considering the available transport statistics, the following observation is valid:

- For road transport, the content of the container is known and assigned to one of the NST categories (0-9);
- For inland navigation and rail transport, the content of the container is not known and assigned to NST category 9.

When considering the NST category as the category containing container flows, road transport is underestimating the container flows.

Advise: Additional research is needed to have a better view on container flows.

5.1.7 Emissions sub-model;

The typical output of the FMF is transport flows expressed in number of vehicles, tonkilometer and vehiclekilometer, but is not containing information on emissions.

Advise: One might consider to carry out further research on the inclusion of emissions sub-model in the FMF.

5.1.8 Linkage with other models.

As noted in section 2.3, a trend in modeling is the combination of expertise of research partners. An example of possible integration of models is the following:

- FMF;
- The RuimteModel Vlaanderen;
- Lambit.

One of the reasons to combine models, is the synergy of activities. Each model has its own characteristics, but is partly containing the same data. By cooperating, it might be easier to collect data. In some cases, data needed in one model is already available in another model.

Advise: Integrated tools and models for policy support in Flanders are needed to design and implement sustainable (port) strategies.

5.1.9 Need for additional data on rail freight transport

When analyzing European freight models, it is always noted that collection of rail freight data is a huge problem. Origin-destination data as well as assignment data is hard to collect.

One of the steps in the FMF is the assignment. After translating the simulated tonnages into the number of vehicles, these vehicles are assigned to the network. For example, this could be done on the shortest path methodology, or the cheapest path methodology. Whatever methodology is used, the result should represent reality as good as possible.

For road and inland navigation, results can be compared with actual traffic counts (when simulating the base year). For rail transport, it is difficult to obtain data about assignment of trains to the wagons.

Advise: the calibration and validation of rail freight transport needs extra support.

5.2 Conclusions from the point of view of user-friendliness

The FMF can be characterized as a software package. Two main options can be distinguished when using this tool:

- Option 1: A potential user obtains a copy of the FMF;
- Option 2: The VC / MINT is not distributing the tool; the potential user is requesting simulations to the VC /MINT.

During the research period 2007-2011, the Research Centre has chosen option 1. The main reason is that this option enables to carry out a detailed assessment of the tool.

Both options have advantages and disadvantages.

- Option 1 has to take into account the aspect of having the software license and involves more working time for the potential user. In 2011, the last version of the Freight Model is not user-friendly;
- Option 2 has the advantage of being more time-efficient when needing results of a simulation.

However, choosing either option 1 or 2, the main common issue is that the FMF should not become a black box. Transparency, next to user-friendliness, is needed, as illustrated in the following points of attention.

5.2.1 Creation of a manual explaining script, input and output files of every block

In 2011, a detailed up-to-date manual of the freight model is not available. The creation of this manual is very important for understanding and tracing the linkage between the variables and the different stages of the model. One should be able to trace and understand the loops connecting the stages of the model in order to make scenarios i.e. choosing the right variables to get the desired effect.

Advise: a comprehensive, up-to-date manual is needed for the user of the FMF, including formulas and methods.

5.2.2 Creation of a manual incorporating examples

The demand for a manual as described in 5.2.1 should not only focus on the theoretical foundations of the model, but should also contain some practical examples.

The reason is that working with the FMF pre-assumes in-depth knowledge of the functioning of the model and hence making it very difficult for a beginner to make applications. Therefore it could be very useful to describe some examples of typical scenarios (“How to...”).

Advise: a manual is needed for the user of the Strategic Freight Model Flanders, including some practical examples.

5.2.3 Creating a user-friendly version of the FMF

As a consequence of 5.2.1 and 5.2.2 it might be advisable to make a user-friendly version of the FMF. The version of the FMF in 2011 needs expertise on the underlying software (Cube).

Advise: It might be useful to create an application on top of the FMF, in which only windows are shown which are needed (for example: input screens) and can be changed by the user. This can also be put in practice by creating an internet application in which the user can fill in input screens which are sent to the VC / MINT.

5.2.4 Creating user-friendly output

In the 2011 version of the FMF, a lot of manual actions have to be undertaken to get the output (e.g. *tkm, vkm*). On the other hand, each application needs specific types of output.

Advise: a list should be made with possible output of the FMF.

5.2.5 Setting up scenarios

Each simulation with the freight model is based on scenarios (reference scenario and alternative scenarios), using an underlying network for the forecast year.

Advise: A suggestion is made to provide the user with some standard scenarios, which can be used immediately. This also involves the provision of ready-made networks to be used.

5.2.6 Differentiated cost functions

The FMF allows simulating, among other things, the effects of changed cost parameters and load factor. These changes are incorporated in a uniform way for the user, meaning that these changes apply to all routes (all origin-destinations).

For example, it might be useful to be able to introduce cost changes on specific origin-destinations (e.g. freight flows passing the Albert Canal).

Another example is related to applying different cost functions to different nationalities of the used vehicle.

Advise: For some applications it might be advisable to allow for differentiated cost functions, meaning that some costs are applied to specific corridors or applications.

6 References

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