

Beleidsondersteunende paper

***LEVIERS AND THREATS FOR
INTERMODAL TRANSPORT -
EVALUATING TRANSFERIA,
LONGER AND HEAVIER TRUCKS
AND USER PREFERENCES***

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LEVIERS AND THREATS FOR INTERMODAL TRANSPORT - EVALUATING TRANSFERIA, LONGER AND HEAVIER TRUCKS AND USER PREFERENCES

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 Business Technology and Operations (BUTO) van de Vrije Universiteit Brussel. Het Steunpunt Goederen- en personenvervoer wordt financieel ondersteund door de coördinerende minister Philippe Muyters, Vlaams minister voor Werk, Economie, Innovatie en Sport en Ben Weyts, Vlaams minister van Mobiliteit en Openbare Werken, de functioneel aansturende en functioneel bevoegde minister.



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Nederlandstalige samenvatting

Deze beleidsondersteunende paper bouwt verder op twee eerdere papers (Meers et al., 2013; Meers en Macharis, 2014) en heeft als doel om de intermodale transportmarkt van morgen te verkennen aan de hand van twee concepten en een keuze-experiment. Een eerste onderdeel focust op de aanbodzijde van transport, namelijk op het effect dat een voertuiginnovatie – de introductie van langere en zwaardere vrachtwagens (LZV's) in Vlaanderen – kan hebben op de intermodale transportmarkt. Ook een tweede sectie focust op de aanbodzijde, maar dan op het vlak van infrastructuur, en evalueert het concept van container transferia, een specifiek type overslagterminals. Een derde sectie tenslotte, focust op de vraagzijde en gaat na hoe het aanbod van intermodale transportdiensten aangepast kan worden om beter tegemoet te komen aan de verwachtingen van verladers en logistieke dienstverleners.

Binnen het LZV proefproject dat aan de gang is, rijden momenteel de eerste LZV's in Vlaanderen. LZV's kunnen er mogelijk voor zorgen dat wegtransport zowel goedkoper als milieuvriendelijker wordt, omdat door schaalvoordelen de gemiddelde kost en uitstoot per getransporteerde eenheid kan dalen. Door het toelaten van LZV's op de openbare weg, kan echter de vrees ontstaan dat een omgekeerde modale verschuiving (*reverse modal shift*) zal plaatsvinden. Dit wil zeggen dat door de kostendaling die in het wegtransport kan gerealiseerd worden door het gebruik van LZV's, er goederenstromen verschuiven van intermodale alternatieven, zoals spoor- en binnenvaartvervoer, naar vervoer met LZV's. Voorbeelden uit andere landen tonen vooralsnog niet aan dat een dergelijke omgekeerde modale verschuiving op grote schaal plaatsvindt. Maar de lessen die in het buitenland geleerd worden, mogen niet zomaar toegepast worden op de Vlaamse context. Deze studie baseert zich op de gerealiseerde kostendalingen uit buitenlandse voorbeelden en toont aan dat het gebruik van LZV's in Vlaanderen het marktgebied van intermodale terminals wel drastisch kan verkleinen. Maar, aangezien LZV's niet in alle situaties gebruikt kunnen worden, is LZV vervoer niet in alle gevallen een alternatief voor intermodaal vervoer. Er moet namelijk aan een aantal randvoorwaarden worden voldaan voordat LZV transport een valabel alternatief wordt. Met betrekking op containervervoer is bijvoorbeeld de beschikbaarheid en daarom ook de balans tussen 20 voet en 40 voet containers cruciaal. Voortbouwend op de in dit onderzoek geïdentificeerde parameters, moet daarom aangetoond worden in welk aandeel van de goederenstromen LZV's een echt alternatief kunnen vormen voor intermodaal vervoer. Binnen dit onderzoek werd bovendien ook nagegaan wat de maatschappelijke impact kan zijn van het gebruik van LZV's, aan de hand van een externe kosten analyse. Deze analyse berekent de externe kosten van emissies (CO₂, SO₂, NO_x, PM_{2,5}), ongevallen, geluid, infrastructuurschade en congestie voor binnenlandse trajecten van en

naar de Haven van Antwerpen. De analyse toont aan dat indien het ongevalrisico niet stijgt, een verschuiving van 'gewone' vrachtwagens naar LZV's een maatschappelijk interessante evolutie kan zijn. Maar, in bijna alle gevallen is intermodaal vervoer nog steeds een beter alternatief dan LZV's, vanuit een maatschappelijk oogpunt. Daarom is het belangrijk om een omgekeerde modale verschuiving zoveel mogelijk te beperken of zelfs te vermijden.

Een tweede onderdeel van de studie evalueert het container transferium concept. Transferia zijn een type intermodale overslagterminals dat zich onderscheidt door hun locatie (in nabijheid van een haven) en door hun functie (de havenomgeving ontlasten van wegverkeer). Zowel in de praktijk als in de wetenschappelijke literatuur wordt het concept echter inconsequent gebruikt, waardoor het onduidelijk is welke bestaande terminals (in Vlaanderen) precies als transferium kunnen gecategoriseerd worden. Uit de analyse blijkt dat het gebruik van een containertransferium de externe transportkosten kan verlagen, in vergelijking met unimodaal wegvervoer. De richting van het natransport is echter belangrijk om deze 'winsten' te bestendigen. In het geval dat het transferium dienst doet als overslagterminal voor lokale volumes, ligt de bestemming van deze goederenstromen best in de richting van het verlengde van het transferium, in de richting weg van de oorsprong (de haven). Indien de laadeenheden vanuit het transferium nog een over een (middel)lange afstand getransporteerd moeten worden, gebeurt dit vanuit een maatschappelijk oogpunt in de meeste gevallen best opnieuw intermodaal. Door de extra overslag die hiervoor nodig is, is deze oplossing in veel gevallen echter een pak minder competitief dan rechtstreeks intermodaal vervoer tussen haven en hinterlandterminal. Indien het natransport vanuit het transferium nog over een lange afstand over de weg gebeurt, blijft de daling in maatschappelijke kosten voornamelijk beperkt tot het transportsegment binnen de havenregio. De maatschappelijke impact van een transportketen die gebruikt maakt van een containertransferium hangt dus sterk af van de lengte van het natransport en of er voor dit natransport al dan niet gebruik gemaakt wordt van intermodaal vervoer. De dubbele functie van transferia weerspiegelt zich ook in de statistieken met betrekking tot de modale verdeling. Daarom is het belangrijk dat wanneer deze statistieken van regio's, landen, havens of intermodale terminals worden weergegeven, er duidelijk wordt vermeld of het gaat over de vervoerde tonnages per vertrekkende/aankomende modus, dan wel of de totale ton-km van het hele traject in rekening worden gebracht en proportioneel aan de gebruikte transportmodi worden toegekend.

Voor het derde deel van deze paper tenslotte, werd een bevraging bij verladers, logistieke dienstverleners en expediteurs georganiseerd om een beter inzicht te krijgen in welke criteria in welke mate een invloed hebben op de transportmoduskeuze in binnenlands containervervoer. De

groep verladers blijkt vaker dan de logistiek dienstverleners of transportoperatoren betrokken zijn in de transportmoduskeuze. De belangrijkste redenen die beide groepen aangeven om niet – of in mindere mate – gebruik te maken van intermodaal transport hebben betrekking op de transportsnelheid, de frequentie van het aantal vertrekken/aankomsten, een ontoereikend dienstenaanbod en onzekerheid over de betrouwbaarheid en de flexibiliteit van intermodaal vervoer. Van de respondenten die aangeven dat ze momenteel geen gebruik maken van intermodaal vervoer, heeft bijna de helft zelfs nooit overwogen om intermodaal vervoer te gebruiken. Hieruit blijkt dat de *mental shift* in Vlaanderen nog niet voltrokken is en dat er dus nog veel mogelijkheden bestaan om bedrijven te benaderen en de mogelijkheden van intermodaal vervoer toe te lichten. Dit kan enerzijds via consultants, zoals momenteel reeds gebeurt, of via (online) tools die de mogelijkheden van intermodaal vervoer verduidelijken. Een kleiner aandeel van de respondenten gaf bovendien aan dat een beperkte informatiebeschikbaarheid een modale verschuiving in de weg staat. Het modale keuze experiment dat onderdeel uitmaakte van de bevraging toont aan dat prijs een belangrijk keuzecriterium is, maar bevestigt ook dat transporttijd – tenminste voor een niet onbelangrijk deel van de respondenten – een belangrijke determinant is in de moduskeuze. Ook de vertrek/aankomstfrequentie van transport wordt duidelijk in de beslissing meegenomen, maar een dagelijks vertrek/aankomst volstaat in veel gevallen. Wat betreft betrouwbaarheid – gedefinieerd als het aantal transporten dat niet binnen het vooropgestelde tijdsvenster aankomt – tenslotte, gaf een groot aandeel van de respondenten aan dat transportalternatieven pas kunnen overwogen worden indien aan een betrouwbare dienstverlening kon worden voldaan. Aangezien intermodaal vervoer zelden of nooit kan wedijveren met wegvervoer qua transporttijd, lijkt het dus belangrijk om diensten aan te bieden die betrouwbaar en goedkoop zijn en dat met een dagelijkse frequentie.

In de conclusie wordt tenslotte kort verwezen naar het concept synchronodaal vervoer dat de laatste jaren sterk aan belang gewonnen heeft in academisch onderzoek en waarvoor ook heel wat verladers, transporteurs en logistieke dienstverleners interesse tonen. Het lijkt dan ook aangeraden om verder te onderzoeken wat synchronodaal transport in Vlaanderen kan betekenen en wat gerelateerde noden en mogelijkheden zijn.

1 Introduction

This paper deals with important elements that can impact the use of intermodal transport in the near future. While the previous policy supporting papers focused on the importance of transport time in intermodal chains, the optimal network configuration of intermodal terminals, the break-even distance of intermodal transport and modal choice decision aid, this paper focuses on three different topics.

A first section anticipates on the trial that is currently conducted with longer and heavier vehicles (LHVs) in Flanders, and deals with the effects of a possible (further) introduction of these vehicles. While LHVs might reduce both the cost and environmental impact of road container transport, their allowance could also enhance a reverse modal shift from intermodal solutions to road transport. This section researches what the impact of an LHV introduction can be on the market areas of intermodal terminals and investigates the societal impact of a shift from the use of 'regular' trucks to LHVs and from intermodal solutions to LHVs.

A second section focuses on the concept of container transferia, a specific type of transshipment terminals. These terminals distinguish themselves from 'traditional' terminals mainly by their location and functionalities. The section focuses on the competitiveness of the concept and its societal impact.

A third section builds on a previous policy supporting paper (Meers and Macharis, 2014) and deals with the topic of modal choice. A choice-based conjoint experiment is conducted to gain insight in modal choice preferences of shippers and logistics service providers (LSPs) in short distance container transport. The findings of this experiment are used to make recommendations to design intermodal services that better satisfy the needs of the respondents.

The general conclusions finally, bundle the results of the previous sections, make policy recommendations and provide an outlook for further research.

2 Longer and heavier vehicles: a green alternative or the start of a reverse modal shift?

2.1 Introduction

By granting a license to the transport operator Ninatrans, the Flemish trial with longer and heavier vehicles (LHVs) really took off.¹ The Flemish LHV trial aims to increase the insight in the effects of allowing LHVs on environment, mobility and road safety.² Contrasting views on the introduction of LHVs between proponents (such as road transport operators) and opponents (such as rail transport operators³) also led to a difference in making reference to the LHV concept (e.g. ecocombi versus mega-truck).⁴ In Flanders, LHVs are described as trucks up to 25,25m long with a maximal total mass of 60 tons.⁵ The ‘regular’ trucks that are currently allowed in Belgium have a maximum length of 18,75m and a maximum total weight of 44 tons. LHV configurations that can be allowed in Flanders are depicted in Figure 1.

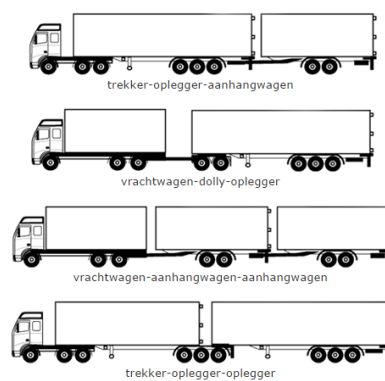


Figure 1 LHV combinations allowed in the Flemish trial (Source: MOW (2015))

¹ <http://ninatrans.eu/v2/2015-primeur-voor-ninatrans-en-ab-inbev-eerste-ecocombi-op-vlaamse-wegen/>

² <http://www.mobielvlaanderen.be/lzv/proefproject.html>

³ At European level, a website has been set up, grouping organisations opposing ‘mega-trucks’. Belgian organizations mentioned on this website include Bond Beter Leefmilieu (BBL) and Netwerk Duurzame Mobiliteit. (<http://www.nomegatrucks.eu/mega-truck-opponents/>)

⁴ A stakeholder analysis study was already performed by Vannieuwenhuysse and De Munck (2007).

⁵ <http://www.mobielvlaanderen.be/lzv/wat.html>

The main rationale for introducing LHV's is to make road transport cheaper and/or to decrease its impact on society, by reducing congestion, emissions etc. The aim of this chapter is, however, to investigate the potential impact of introducing LHV's in Flanders on the market areas of intermodal terminals, using a location analysis model. To make meaningful simulations, it is assumed that these LHV's can be allowed for transport between all locations in Flanders.⁶ Next, the societal impact of such a potential reverse modal shift is estimated by calculating changes in the external costs due to such a reverse modal shift.⁷ Avoiding a reverse modal shift should not be a goal as such, unless a clear negative societal impact of such a shift can be shown.

An important aspect with regards to the avoidance of a reverse modal shift, is described in the 20/12/2013 Decision of the Flemish Government (Belgisch Staatsblad, 2014). Article 3 mentions that: *'Het vervoer met langere en zwaardere slepen wordt niet toegelaten voor: [...] 5° een goederenstroom die op het ogenblik van de vergunningsaanvraag via het spoor of de binnenvaart verloopt.'* This precondition should guarantee that no reverse modal shift can take place during the trial phase. But with respect to a possible broader allowance at a later stage, it will be difficult to derive relevant information regarding the risk on a reverse modal shift from this trial. In addition, it is also possible that 'new' transport flows will start using LHV's, while they might have used intermodal alternatives if LHV's would not have been allowed.

2.2 Benefits of using LHV's

Regions such as Flanders, suffering heavily from road congestion, are triggered to come up with innovative solutions. But besides congestion, freight transport also generates other negative societal impacts such as emissions, accidents, infrastructure damage and noise (Delhaye et al., 2010). Increased load factors of trucks help in decreasing the societal impact per unit transported. The basic rationale for allowing LHV's is thus that more goods can be transported at the same time, decreasing the transport costs per transported unit of cargo, while simultaneously reducing the truck emissions per unit of transported cargo, by increasing the loading capacity per vehicle (Table 1). For the

⁶ And therefore, the simulations described are not limited to the current trial road network.

⁷ Bickel and Friedrich (2005:9) define external costs as: *"an external cost arises, when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group"*. The external costs are thus calculated to estimate the societal impact of shifting transport operations from one mode or technology to another.

transport of large and/or voluminous loads, three regular trucks can be replaced by two LHVs. This will result in both a reduction in the amount of vehicle-km and ton-km.

Table 1 Comparison of loading capacity between LHV and truck-trailer combination (Source: based on Debauche and Decock (2007))

Technical characteristics	Truck + trailer (18.75m/44t)	LHV (25.25m/60t)	Gain in loading capacity (%)
Loading length (m)	15.65	21.4	+37
Loading capacity (t)	29	40	+38
Loading capacity (m ³)	112	156	+39
Loading capacity (#EuroPallets)	38	53	+39

According to De Ceuster et al. (2008), the cost for road transport would be reduced by approximately 20% and the fuel consumption by approximately 12.45% per ton-kilometer when replacing regular trucks by LHVs in Europe. A study of ARCADIS (2006) even mentions that fuel consumption can be reduced by 33% to transport the same amount of goods. Also the average labor costs can clearly be decreased, as fewer drivers are required to transport a same amount of goods, assuming a sufficient loading rate.

Also society at large can benefit from the introduction of LHVs. When LHVs are efficiently used, the total external transport costs per ton-kilometer can be decreased when replacing regular trucks (De Ceuster et al., 2008). To gain insight in the societal impact of a shift from regular trucks to LHVs for a specific case study region, an external transport cost analysis should however be performed, to include effects of emissions, accidents, congestion, noise, infrastructure wear and tear etc. But obviously, lessons can also be learnt from foreign experiences with LHVs, regarding the impact of these vehicles on the modal split and the resulting effects on inter alia internal and external transport costs. These aspects are discussed in the following section.

2.3 LHV's abroad

In Europe, most countries allow truck combinations with a maximum length of 18.75m and a total weight of 40 or 44 tons (ITF, 2013a,b). Different countries, however, eased regulations and allow longer and/or heavier vehicle combinations (on parts of their road network) (Figure 2).⁸

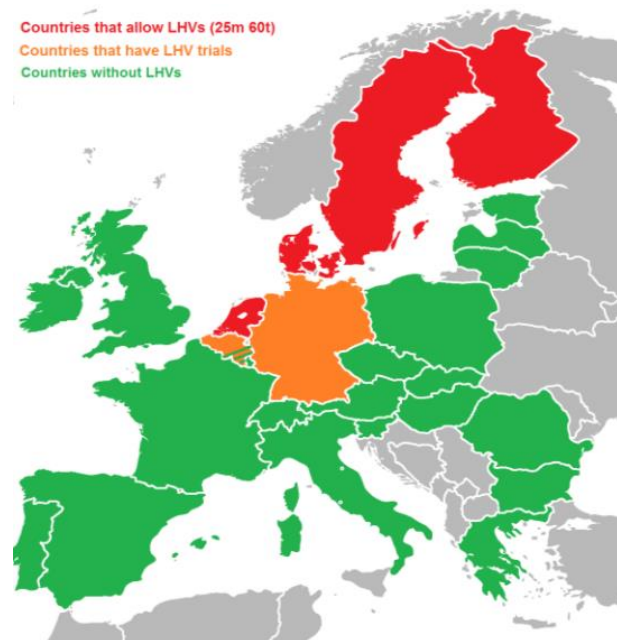


Figure 2 European countries allowing LHV's (Source: Transport and Environment (2013))

2.3.1 Risk on reverse modal shift

The concept of freight transport cost elasticities (Beuthe et al., 2014) implies that cost reductions in road transport will induce a shift from intermodal rail and inland waterway transport to unimodal

⁸ A relevant concept in this context is the European Modular System (EMS), referred to in Directive 96/53: 'the Member State which permits transport operations to be carried out in its territory by vehicles or vehicle combinations with dimensions deviating from those laid down in Annex I also permits motor vehicles, trailers and semi-trailers which comply with the dimensions laid down in Annex I to be used in such combinations as to achieve at least the loading length authorized in that Member State, so that every operator may benefit from equal condition of competition (modular concept).' Later, Directive 2002/7/EC of the European Parliament, allowed member states to experiment with LHV's on their territory, making it possible to deviate from the former directive.

road transport. When LHV's can be used for pre- and/or post-haulage transport, this effect will however partly be compensated (Jourquin et al., 2014). The consequence of a reverse modal shift might be that the societal gains of replacing 'regular' trucks by LHV's can be nullified when intermodal transport chains are also substituted by LHV chains. As on average intermodal transport has a smaller environmental impact compared to road-only transport (see e.g. Kreutzberger et al., 2006), a substantial reverse modal shift might have far-reaching implications.

Other countries or regions have preceded Flanders by allowing LHV's, but as they might differ in inter alia spatial planning, market conditions and transport networks, the allowance of LHV's cannot simply lead to the copy-pasting of best practices.

2.3.1.1 Scandinavia

Sweden and Finland allow 25.25m long trucks with a maximum weight of 60 tons when complying with the EMS. Already in 1968, Sweden allowed road trains of 24m (Åkerman and Jonsson, 2007) and recently, 30m long vehicles with a maximum weight of 90 tons are used for timber transport, leading to cost and fuel consumption reductions (Löfroth and Svenson, 2012). Restricting the vehicle length and width to the common European standards now, would lead to financial losses, an increase of transport-related emissions and industrial disadvantages, according to Åkerman and Jonsson (2007). Sweden and Finland nevertheless have relatively high modal shares for rail transport, corresponding to respectively 39.7% and 26.6% of the continental transport ton-kilometers in 2012 (Eurostat, 2015). Besides, the introduction of EMS in 1997, did not lead to a decrease of the rail modal share in Sweden (Åkerman and Jonsson, 2007).⁹

2.3.1.2 The Netherlands

In the Netherlands, LHV's have been gradually introduced during a number of consecutive trial periods. A study from ARCADIS (2006) concluded from the second trial period, running from 2004 until 2006, that (following the conditions of this trial) only a limited reverse modal shift would take place, corresponding to a reduction of 0.2-0.3% of the transported volume for inland waterway transport and 1.4-2.7% for rail transport.

In 2010, the share in the container transport transported by LHV's was estimated to be 1.8%, with LHV's being mainly used for direct transport between the port and its hinterland and not for pre- or

⁹ This might have been a consequence of the fact that EMS also enabled intermodal transport.

post-haulage (Ministry of Infrastructure and the Environment, 2011). The same study concluded that a reverse modal shift was not expected in the future, as LHV's cannot meet certain quality requirements of intermodal chains.¹⁰ Since 2013, the number of allowed LHV's is no longer restricted, but LHV's can still run only on approved routes.

2.3.1.3 Germany

Recently, Germany set up a trial, with longer (25.25m) but not heavier vehicles (still 40/44tons) in different federal states on a limited road network. Therefore, the focus in Germany is mainly on shifting transport flows of goods with a very low specific weight (Glaeser and Irzik, 2014). Rail transport on the other hand is mainly favorable for the segments of heavy goods - and long distance transport.

2.3.2 External costs

As transport operations can evoke negative societal effects such as congestion, accidents, noise, infrastructure wear and tear, air pollution, climate change etc., external costs analyses can be used to estimate the societal impact of an LHV allowance. LHV's have a greater societal impact than regular truck on vehicle level, but as LHV's can transport additional weight and volume, their efficiency can be 15-25% higher per ton-kilometer (De Ceuster et al., 2008). Linked to the increased fuel efficiency, also the emissions per ton-kilometer can be reduced when using LHV's. Kraaijenhagen et al. (2014) find that CO₂ savings can range between 11 and 33%.

The impact of LHV's on infrastructure wear and tear is related to the amount of axles. The maximum load per axle might not increase when the weight can be spread over more axles (Leduc, 2009).

Regarding the accident risk, Brijs et al. (2007) find that when preconditions regarding road infrastructure and technical resources are met, the accident number will not increase when replacing regular trucks by LHV's in Flanders.

Impacts on congestion are difficult to estimate, but in general, road space will be freed up as the number of trucks on the network can be reduced. The indicator values that are used to calculate the

¹⁰ These requirements included the ease of monitoring multiple containers on a barge or train; the fact that the LHV cost structure is less suitable for short distance transport and that there are limited possibilities to combine one 20ft. with a 40ft. container or three 20ft. containers, due the imbalances in container flows and weight restrictions.

external costs of the transport chains in Flanders, used in the analysis, are discussed in the next section.

When the total external cost of LHV transport is lower than the external costs of using a regular truck per transported unit, replacing regular trucks by LHVs would bring a societal (net) benefit. But, a reverse modal shift from rail and inland waterway transport to LHVs can decrease or even nullify these societal gains on other transport links. When only small transport volumes would shift away from intermodal transport chains, this can even enhance a domino effect when critical transport volumes can no longer be transshipped in a terminal, which can result in shutting down intermodal services (De Ceuster et al., 2008).

2.4 Methodology

This study combines two methodological approaches. First, the spatial impact of price reductions in road transport (as a consequence of using LHVs) on the market areas of intermodal terminals is simulated using the LAMBIT model.¹¹ Using a price comparison, the model calculates the transport flows that are most likely to divert from intermodal to LHV transport services. Second, an external cost analysis is conducted in LAMBIT to calculate both the societal impact of a potential modal shift from regular trucks to LHVs and from intermodal transport to LHVs.

The LAMBIT output images visualize the intermodal terminal market areas that can be defined as the entities that can be served cheaper by intermodal transport than by unimodal road transport. The model uses a shortest path algorithm to calculate transport distances between two locations and couples these with mode-specific price functions, which are derived from market surveys.¹² To simulate the impact of LHVs in LAMBIT, the road transport price functions are changed based on price reductions in foreign experiences.

The same shortest path algorithm also allows calculating the marginal external transport costs of transport trajectories. The external costs included in this analysis are emissions (CO₂, SO₂, NO_x, PM_{2,5}), accidents, noise, infrastructure wear and tear and congestion. In addition, LAMBIT allows letting these external costs vary, depending on location, road/waterway type and vehicle capacity

¹¹ An extensive description of this model can be found in Meers et al. (2013).

¹² For more elaborate information on the cost functions used in the model, we also refer to Meers et al. (2013)

when relevant. A detailed description of the methodology and the external cost indicator sources can be found in appendix.

2.5 LHV's in Flanders

In 2006, OCW investigated the interest among carriers with at least six trucks in the use of LHV's in Belgium (Debauche and Decock, 2007). 53% of the respondents believed that LHV's could be an alternative for their company. The interest was greatest in the segments of general - and container transport.

In this simulation, it is assumed that in a later stage LHV's are allowed on the whole Belgian road network.¹³ Only maritime-based transport chains to the Port of Antwerp, the main domestic market where trucks and intermodal transport compete, are considered. Following 2012 statistics, the Port of Antwerp relies for 9% on rail and for 35% on inland waterway transport for its hinterland transport of containers (Port of Antwerp, 2014). The focus is on container transport, where regular trucks can carry one 40ft. or two 20ft. containers, while LHV's can carry up to one 40 ft. and one 20ft. or three 20ft. containers at the same time.¹⁴ This can however only be the case if weight restrictions are not violated. The capacity of trains depends mainly on the number of wagons, the capacity of barges on the vessel size, bridge heights etc.

The first subsection discusses the spatially differentiated risk on reverse modal shift and the second subsection deals with the corresponding marginal external cost estimates for reverse modal shift on these same transport trajectories.

2.5.1 Intermodal terminal market areas

In this case, only transport price is considered as differentiating factor between regular trucks and LHV's.¹⁵ The potential impact of the competition between LHV's and intermodal transport in Belgium

¹³ Clearly, this implies that reverse modal shift would no longer be explicitly forbidden. New transport operations can in no case be subject to the current regulation, what makes that the power of this restriction fades in the longer term, as flows that would have been transported by intermodal transport in the case that no LHV's would be allowed are not subject to it.

¹⁴ This obviously requires an appropriate distribution of 20ft. and 40ft. containers.

¹⁵ Also qualitative criteria can be decisive in decision making, as discussed in chapter 4 of this paper.

is analyzed by simulating price reductions. Price reductions of 5%, 15% and 25% were simulated as no insights in the transport price reductions of the Flemish LHV trial are yet available. The estimated price reductions are based on the findings of Aarts and Feddes (2010) who state that for the Dutch case, LHVs can reduce the road transport costs for a roundtrip by 25%.¹⁶ It is taken as an assumption, following Bergqvist and Behrends (2011), that the same price reductions can be achieved in post-haulage transport, even though these transport distances are usually rather short.

The figure below shows how the market areas of intermodal terminals shrink as a reaction to price reductions in road transport. The number of municipalities that belong to intermodal terminal market areas in Flanders decreases by 15% for a price decrease of only 5%, by 63% for a 15% price decrease and by 91% for a 25% price decrease. It should however be noted that no data were available on the origins and destinations of the containers transshipped in these terminals, so no exact estimates of the reductions in transshipment volumes could be made. It could be assumed that a higher share of volumes is currently transported to companies in the vicinity of terminals, and a lower share to more remote locations. Besides, not all transport flows going to or from these market areas are currently served by intermodal transport.

¹⁶ Backman and Nordström (2002) estimate cost savings of 23%.

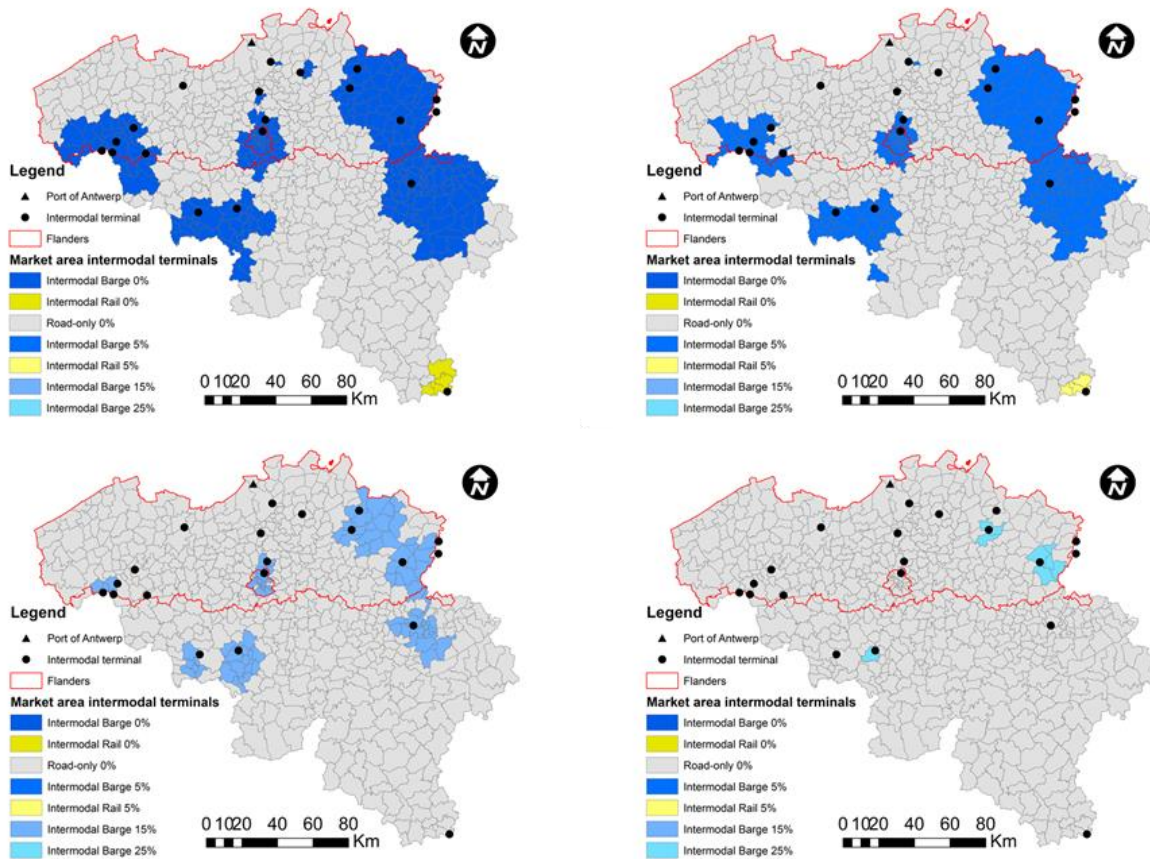


Figure 3 The market areas of intermodal terminals shrink when prices of road transport decrease. The 0% (top left), 5% (top right), 15% (bottom left) and 25% (bottom right) refer to the decrease in the road transport market prices following the allowance of LHVs.

2.5.2 External costs

Using the input data and assumptions described in appendix 7.1, Table 2 provides the marginal external cost 0 ranges per vehicle type included in the external cost simulations. For road transport, two scenarios are considered based on congestion levels (a mainly congested network versus almost free flow traffic). It is clear that the congestion level can have a big impact on the total external cost, given the wide range of the estimated external cost of road congestion.

Table 2 External cost (ranges) per vehicle type (€/vehicle-km)¹⁷.

	CO ₂	SO ₂	NO _x	PM _{2,5}	ACC	NOI	INF	CON
Regular truck	0.07-0.14	0.00-0.00	0.07-0.14	0.00-0.07	0.01-0.03	0.00-0.10	0.08-1.07	0.00-2.13
LHV	0.10-0.19	0.00-0.00	0.09-0.17	0.01-0.08	0.01-0.03	0.00-0.10	0.04-0.57	0.00-2.33
Diesel train (400-575m)	0.89-1.02	1.66-1.89	0.04-0.05	0.14-0.99	0.09-0.12	0.03-1.39	0.45	0.21-0.30
Electric train (575m)	/	/	/	/	0.12	0.03-1.39	0.45	0.30
Barge	0.29-1.70	0.03-0.16	0.51-2.89	0.05-1.64	0.01-0.08	/	0.08-1.51	/

ACC=Accidents, NOI=Noise, INF=Infrastructural damage, CON=Congestion

A first simulation shows the effect on the total external cost for the transport of 1 TEU when replacing regular trucks running in congestion by intermodal chains (left) or LHVs (right) (Figure 4). It is assumed that for the intermodal alternative, the cheapest alternative is chosen and that post-haulage operations can be performed outside the congestion period. Green areas indicate that a shift can bring societal gains, yellow and red areas indicate societal losses. Both images clearly show the positive effects of shifting to intermodal and LHVs. External transport costs could be reduced on almost all connections, except for some short distance intermodal transport operations. This is mainly caused by detours and/or long drayage distances when opting for the intermodal alternative, compared to the direct truck route. By comparing both maps, it becomes clear that a shift to intermodal is not always preferred to a shift to LHV transport. If regular trucks can also operate outside congestion periods, a shift to intermodal would clearly bring less societal gains than depicted in the figure.

¹⁷ Different types of barges and different train lengths are included in the analysis, (partly) explaining the external cost ranges. The next parameter explaining the external cost ranges are the two scenarios that are considered, with different congestion levels. The third parameter finally relates to differences in time, location and infrastructure.

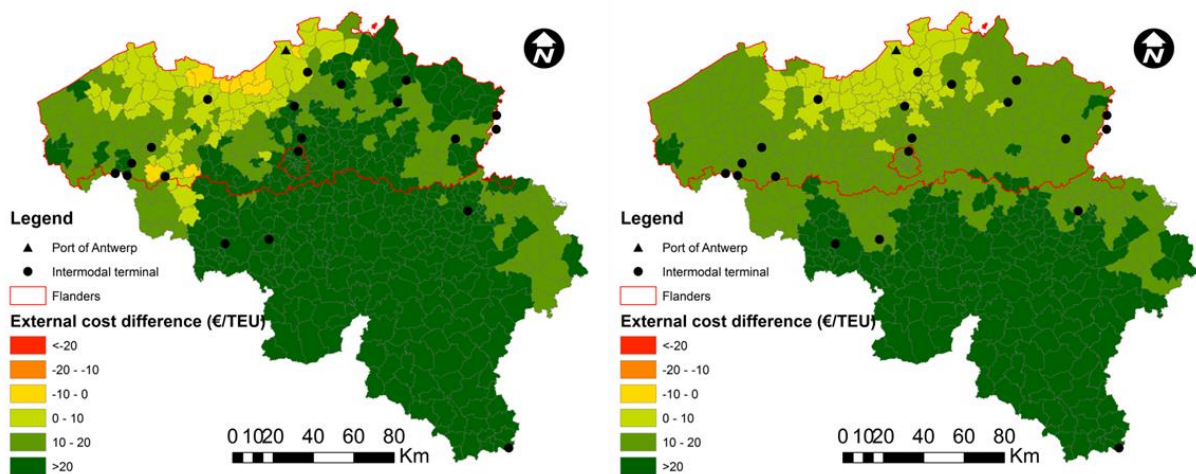


Figure 4 Marginal external cost difference (in €/TEU) for transport between the Port of Antwerp and the municipalities in Belgium when replacing regular trucks by intermodal transport chains (left) or LHVs (right)¹⁸

When focusing on the initial market areas of the intermodal terminals, as simulated in Figure 3 (top left), the external costs difference between intermodal and LHV transport is calculated (Figure 5). A scenario where LHVs are operated in congestion (left) can be compared to one where LHVs can operate in almost free flow conditions. The left image shows that when road congestion occurs, in all municipalities belonging to market areas, intermodal is preferred from a societal perspective. And even when the LHVs operate outside congestion periods, almost all municipalities are colored green, indicating that the use of intermodal transport brings fewer marginal external costs than LHV transport.

¹⁸ Positive values indicate societal gains.

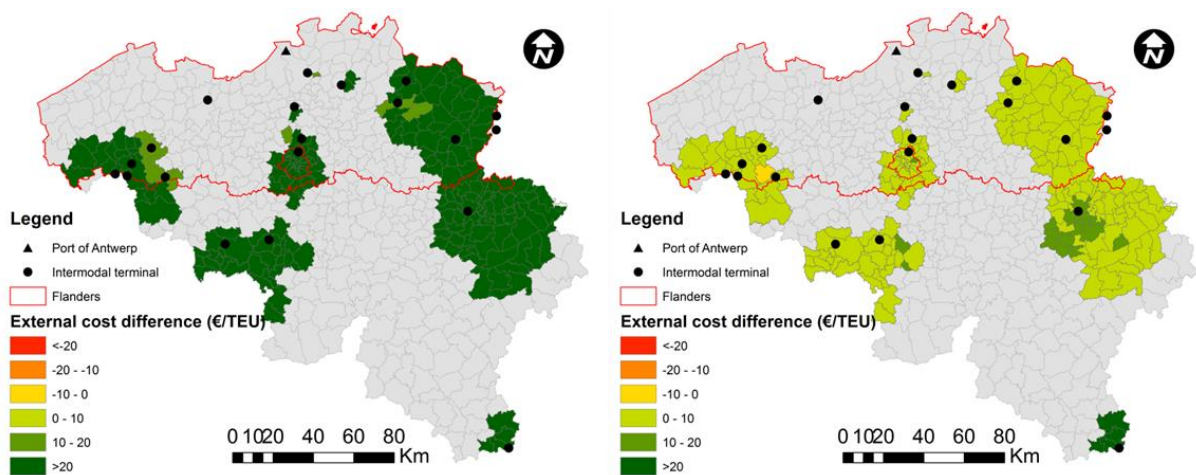


Figure 5 Marginal external cost difference (in €/TEU) for transport between the Port of Antwerp and municipalities in Belgium between LHV – running in congestion (left) and in a free flow traffic (right) – and intermodal transport, focusing on the initial intermodal terminal market areas.¹⁹

The first analysis thus shows that LHVs can be an interesting alternative for regular trucks, when comparing their societal impact, given the assumption that the accident risk does not increase. It seems from the second analysis that LHVs cannot prove to be an acceptable alternative for intermodal transport, at least not in the areas where intermodal transport can currently be competitive. When LHVs run outside congestion periods, the difference in societal impact is, however, less pronounced. In other municipalities, LHVs can be a societally beneficial alternative to regular trucks. Improving the intermodal accessibility in these regions, could on the other hand also make intermodal transport competitive and preferable from a societal perspective.

2.6 Conclusion and outlook

This chapter showed that if LHVs can decrease the transport price of road transport considerably compared to regular trucks, the impact on the competitiveness of intermodal transport services for container transport can be substantial²⁰. Foreign experiences show that replacing regular trucks by LHV's can bring cost reductions up to 25% in road freight transport. The LAMBIT simulations suggest that even more modest price decreases in road transport can make the market areas of intermodal terminals shrink in spatial extent. It should however be noted that no foreign case seems to exist

¹⁹ Positive values indicate societal gains.

²⁰ On the markets where both compete.

where a real (extensive) reverse modal shift has taken place. Therefore it should be investigated to what extent other factors will influence a reverse modal shift, in case that LHV's will be widely allowed in Belgium. These additional research questions are listed in Table 3. It is questionable if the current Flemish trial will help in answering many of these questions, mainly due to the limited number of LHV allowances.²¹

Table 3 Additional research questions to estimate the extent of a (possible) reverse modal shift in Flanders

How much can road prices be reduced in Flanders, when using LHV's?
Which product groups will/can (not) shift to road transport?
Which share of containers can be transported on LHV's, following weight restrictions?
Where can the road network (not) facilitate LHV's?
How are the origins/destinations of 20 ft. and 40 ft. containers spatially distributed? To what extent can they be combined on LHV's?
What are critical volumes for intermodal services to continue operations?
In which cases could LHV's be used for drayage transport in Flanders?
How are the volumes transshipped in intermodal terminals spatially distributed in their market areas?
To what extent do logistics requirements hinder or facilitate the use of LHV's in Flanders?

The societal impact of regular trucks was compared both to the one of intermodal transport and to the one of LHV transport. Based on the assumptions made, LHV's are a good alternative for regular trucks from a societal perspective, in particular when regular trucks have to operate during congested periods. It was, however, also shown that a reverse modal shift from intermodal transport to LHV transport is not desirable, when focusing on the regions where intermodal transport can be operated competitively. In other locations, LHV's can still bring societal gains, when replacing regular trucks. But to gain insight in the total external costs of the transport system, a transport flow analysis should be performed, which takes into account the volume of transport flows that would shift from one mode to another. Regarding rail transport, the analysis could be extended by the inclusion of up- and downstream emissions, which were not included in this study.

²¹ The evaluation of the trial focuses, following Belgisch Staatsblad (2014), on accident statistics, loading characteristics (type, degree, goods, trip number, fuel consumption), the relation between transport modes and type of goods, origin and destination and the number of violations by LHV's.

As possible mitigation measure, Vannieuwenhuyse and De Munck (2007) suggest that the selection of approved routes can decrease the risk on reverse modal shift. A policy framework can be developed to prohibit or limit the use of LHVs for container transport in the areas where intermodal solutions provide a good alternative to road transport. This issue also becomes relevant in the discussion on cross-border transport by LHVs.

3 Container transferia: a solution to port congestion?

3.1 Introduction

Container transferia, a specific type of inland transshipment terminals, have been advocated as an important solution to the problem of port congestion. Academic research on the topic is scarce, however, which might relate partly to the indistinctness of its conceptualization. The past decades, a multitude of inland transshipment concepts has appeared, necessitating clear definitions and characterization of the related concepts. Therefore, we start this chapter by discussing the definition and characteristics of the concept. This chapter will thus first conceptualize container transferia. The second section deals with two case studies, describing existing container transferia. A third section finally will assess the concept both from a price-competitive and a societal viewpoint.

A specific characteristic of a transferium relates to its **location**. According to Defares (2011), the Port of Rotterdam states that a transferium is located in the immediate hinterland of a port. Warffemius and Francke (2010) locate transferia just outside the port area. de Langen et al. (2012:90) situate this type of inland terminal “outside the congested port access highway”. de Langen (2012) also stresses the importance of its location close to the port, to be able to serve a market which is sufficiently large. The further a transferium is located from the port, the less flows it will be able to deal with in a ‘logical’ way.²² Kreutzberger and Konings (2013) describe a transferium as a begin- or end-terminal of land networks, pushed out of the port or another large node and located close to that relieved node (Figure 6). Examples of locations can be the landside of the port or an inland node, located a bit further away (Figure 7). When located outside the port, Kreutzberger and Konings (2013) stress the importance of a location with good access to all or at least many hinterland corridors of the port.



Figure 6 Transferium, taking over the role of the deep sea terminal (Kreutzberger and Konings, 2013)

²² This means: without requiring big detours.

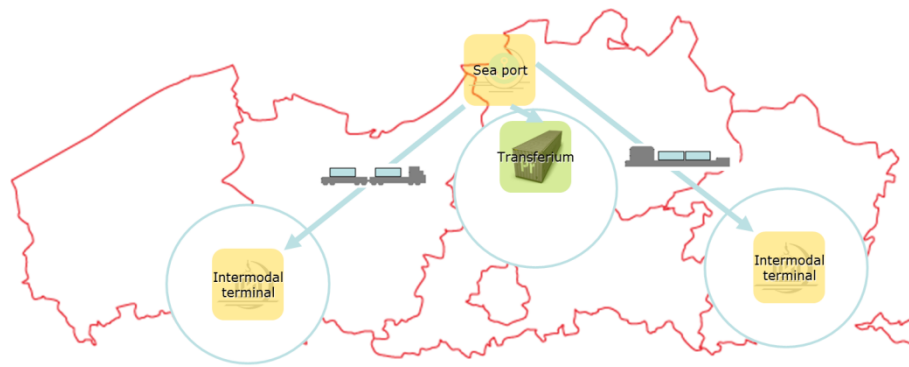


Figure 7 Location of transferia and intermodal terminals, relative to a sea port

The **basic idea** of a transferium is to bundle (container) flows from the port to this transferium, taking advantage of scale economies in the transport and the terminal operations. This is important, as de Langen (2012) states that scale economies are necessary to achieve a competitive transport services, when compared to direct truck transport, which is a prerequisite for a transferium. Defares (2011), following the Rotterdam port authority, states that the basic idea of a transferium should be the achievement of a modal shift from road to inland waterway transport.

Focusing on the different **transport modes** involved, the transferium concept allows truck operators to pick up and deliver their containers at the transferium instead of at the deep sea terminal (De Langen et al., 2012). In the transferium, the containers are bundled for transport to the port using barges or even by trucks (Kreutzberger and Konings, 2013). Although the possibility of using rail transport can also be considered. The transport of trucks could be motivated, when this allows a better spread in time of the containers arriving in the deep sea terminals, or by possible avoiding traffic in peak hours.²³

Different gains can be achieved by applying the concept in practice. As trucks can drop off and pick up their containers at the transferium instead of at the deep sea terminal, they do no longer need to travel across the port and the most congested area. This can reduce congestion problems in and around the deep sea terminals and improve the air quality in the port, by reducing CO₂ and NO_x emissions (Froeling et al., 2008). Besides, the transferium ground can also be used for the stocking of empty and full containers for a longer time (van der Steen, 2010). And if big volumes can be

²³ The concept of a trailer parking outside the congested area around a port has been researched by VIM, VUB-MOBI and Phidan (van Lier et al., 2015).

transported between port and transferium, the service frequency can be kept high, improving the service flexibility. A crucial aspect might however be how the **rest of the transport** (from transferium to end-destination) is performed (Figure 8). One possibility is to do it the intermodal way. This provides an extra bundling opportunity, as no other barges – besides the shuttle service between port terminals and transferium – have to navigate to the ports to pick up or deliver small volumes, as is current practice (Warffemius and Francke, 2010). These barges are not prioritized and they might interfere with the terminal planning of loading and unloading sea vessels. Using the transferia concept, deep sea terminals will have fewer barges calling for the transport of the same container volume. This allows for a better planning at the quays and can decrease the number of disturbances. Eventually, this can improve the terminal capacity utilization and decrease waiting times of the barges.

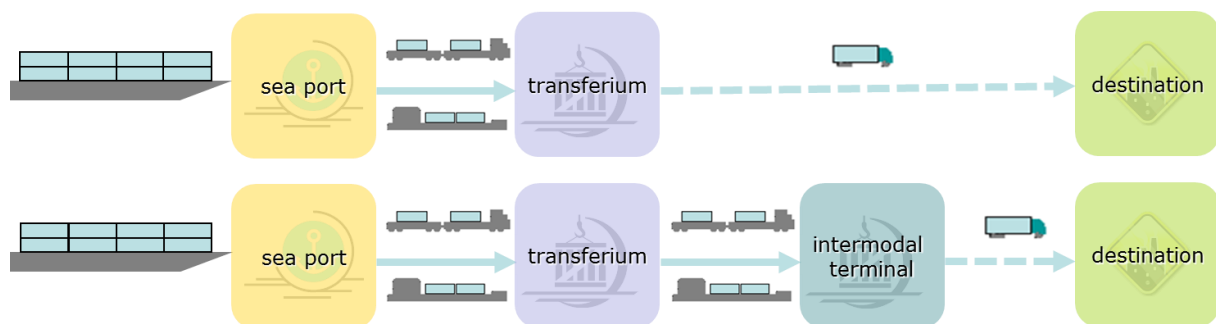


Figure 8 A transferium as hub for barge/rail to truck transshipments (top) and a transferium as barge to barge or rail to rail transshipment hub (bottom)

Following the above, transport time reliability of road transport operations to/from the transferia can drastically be improved as the congested area is avoided. A concern here is that this might enhance the use of road transport instead of intermodal solutions, as transport quality can be improved (Warffemius and Francke, 2010). This makes it questionable whether the modal share of inland waterway transport can be increased overall, when considering the total transport chain. Especially for longer transport distances, this might lead to relatively low societal gains.

One of the questions derived from the previous section, is how are transferia different from other types of inland terminals? Functional and locational differences between terminals have already

been discussed in the 'Beleidsnota consolidatiepunten'²⁴. The difference lies thus mainly in its location, its functionalities and goals (Figure 9). The functionalities can however be rather similar, as both transferia and other inland terminals can act as depot for full and empty containers, do customs clearance etc., leaving the location (and the market it serves) as the main distinctive feature.

	Inland Hub	Container Transferium
Functions	<ul style="list-style-type: none"> • Extension of the seaport • Consolidation and deconsolidation centres • Depot for empties • Temporary storage • Cargo bundling point • Broader logistics zone; container repair, VAL activities, forwarders etc. • Truck-Barge 	<ul style="list-style-type: none"> • Extension of the seaport • Consolidation of container flows • Depot for empties • Enable a reliable transport system between the transferium and terminals in the seaport • Customs bonded • Truck-Barge / Barge-Barge
Goals	<ul style="list-style-type: none"> • Prevent overcrowding of the seaport area / manage traffic • Limit negative externalities of growing volumes • Increase throughput in the port and inland 	<ul style="list-style-type: none"> • Reduce congestion around the port • Reduce environmental problems • Improve efficiency of deep sea terminals • Buffer for peak moments • Optimise barge handling of small parties • Modal shift
Location	<ul style="list-style-type: none"> • In the vicinity of its service area of loading/unloading, remote from the seaport 	<ul style="list-style-type: none"> • Close to the major facility (seaport)

Figure 9 Differences and similarities between transferia and other inland hubs (Source: Market-up consortium (2012) based on Schoonen (2008))

An interesting (related) concept is the extended gate²⁵. Extended gates are, according to Warffemius and Francke (2010), inland terminals that perform customs services that traditionally take place at the deep sea terminal. Visser et al. (2012) describe the extended gate concept of ECT as paperless, frequent and reliable transport between deep sea terminals and inland terminals. In this case, it is the deep sea terminal manager, who organizes the hinterland transport.

²⁴ See also Macharis et al. (2012). We also refer to Roso and Lumsden (2010) and Roso et al. (2009) for further reading on the conceptualization of dry ports, Rodrigue et al. (2010) on inland ports and Iannone (2013) on extended gateways.

²⁵ Which is not the same as the extended gateways concept, introduced in Flanders by Vlaams Instituut voor de Logistiek (2009).

3.2 Case studies

3.2.1 The Netherlands

The most famous transferium, or at least the one that is most discussed in literature, is the one in Alblasserdam. This location was chosen, close to the port of Rotterdam, to be able to serve a sufficiently large market (de Langen, 2012). Roughly 30% of all trucks transporting containers to and from the port, pass there on the A15. The terminal, with a capacity of around 200.000 TEU, was initiated by the Port of Rotterdam and is located at 60 km from Maasvlakte II (Warffemius and Francke, 2010). Recently, the transferium was opened, providing daily services to the terminals in the Maasvlakte and guarantying a next day delivery (BCTN, 2015).

Froeling et al. (2008) evaluated the transferium concept in relation to the Port of Rotterdam, prior to its implementation, using a cost model. Their findings include that both regarding total cost and capacity utilization, visiting the different sea terminals, instead of dedicated visits performs better when designing the transferium shuttles. Also small barges are preferred to bigger ones, given their lower total transport time. When looking at generalized transport costs, including time and reliability aspects, they believe the concept can be successful.

Other inland terminals in the Netherlands which are referred to as transferia are Alpherium in Alphen aan den Rijn and the terminal in Moerdijk, situated in between Antwerp and Rotterdam. Also the terminal in Ridderkerk is referred to as a transferium and is located close to Alblasserdam. Kreuzberger and Konings (2013) state that both transferia (will) have very similar functions, although the one in Alblasserdam should operate on a much larger scale. Defares (2011) however concluded from expert interviews that no additional transferia are required in the Netherlands, as already many (tri-modal) terminals are available. Also the success of current transferia should be evaluated first, before extending the concept to other locations.

3.2.2 Belgium

The Beverdonk container terminal located in Grobbendonk at about 32km from the Port of Antwerp, is often referred to as a transferium (Market-up consortium, 2012a). Located along the E313 and close to the junction with the E34, it is located at a strategic spot. The transferium is owned by DP World, but also the Port of Antwerp has a share in it. Nevertheless, the transferium has an open access policy and the shuttle service visits different terminals in the port.

The Beverdonk transferium has three functions: dealing with local container volumes and acting both as a truck and a barge bundling hub (Kerstens, DP World, in Market-up consortium (2012b)). The

focus for modal shift is on time-sensitive goods that are currently transported by road to and from the Ruhr region, as non-time-sensitive goods are already often transported by barge. In addition, they already perform additional services such as container repair, fumigation, stuffing, stripping and long and short term storage. Following the Market-up consortium (2012b) the main advantages of the transferium are:

- Road transport operations efficiency is improved, while congestion in and around the port is reduced
- The modal split of the Port of Antwerp is improved
- Inland waterway transport performance is improved, as less barges will have to go into the port because of container bundling
- Logistics operations are moved closer to the (final) origin or destination of the goods

The transferium was initiated with subsidies from the Flanders region and the European Fund for Regional Development. These subsidies had three goals: the enhancement of a modal shift, an increased efficiency of inland waterway transport and an improved reliability through inland waterway transport (European Commission, 2011a).²⁶ The European Commission (2011a) also stated that according to the Belgian authorities, the transferium has other activities and target groups than other inland terminals and it would only have a small (negative), limited and temporarily impact on the transshipment volumes of other terminals.

When looking at the map of intermodal terminals in Flanders, besides Beverdonk also the terminals in Deurne and Willebroek might function as a transferium (Figure 10). While Grobbendonk is on the border of the 'traditionally' congested area (Figure 11), the terminal in Deurne is already within that zone. This terminal is might therefore be located to close to the port (about 15 km from the terminals) to function as a transferium, as defined above. Notteboom (2013) classifies the terminals in Willebroek and Meerhout as transferia, besides Beverdonk. He describes a three tier system, with besides the transferia close to the port, a second tier of inland terminals such as Kortrijk, Athus and Liège and hinterland corridors to France, Spain, Italy, Switzerland etc. in the third tier. Kreutzberger and Konings (2013) even consider the rail terminal in Kortrijk as a transferium. Focusing on the spatial logic of transferia and the existing terminals, Beverdonk could serve the eastern market of

²⁶ This document also states the required price ranges for transshipment in the terminal. The average unit price that needs to be charged is €17-21 per truck move, €18-22 per barge move and €2.5-7.5 per day of container storage for a period of more than 5 days (European Commission, 2011a).

Antwerp, while the location of Willebroek could allow serving the southern market. Finally, the western market could be served from Ghent, although the distance to the Port of Antwerp already becomes substantial. This might also fit in the ambition of the Port of Ghent, to be a decongestion port for the ports of Antwerp, Rotterdam and Zeebrugge (Ghent Port Company, 2010). A previous study from Meers et al. (2013) did not show any suitable location for an additional intermodal terminal located closer to the port, that can sustain a local market and that could function as a transferium serving this same western market.



Figure 10 Flanders inland terminal landscape (Source: VUB MOBI in Meersman et al., 2015)

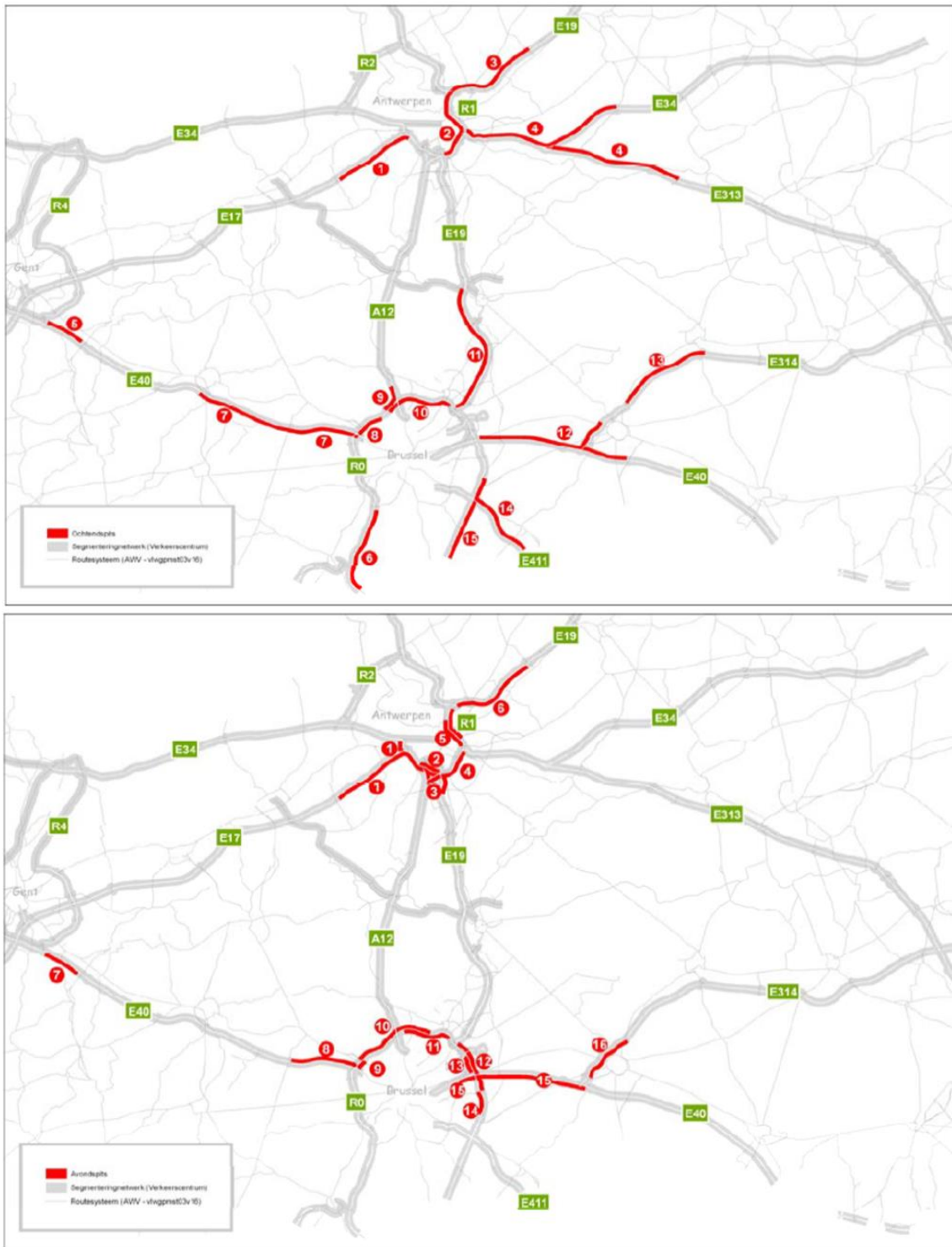


Figure 11 Structural morning (top) and evening (bottom) congestion in Flanders (Source: Vlaams Verkeerscentrum (2014))²⁷

²⁷ Congestion occurs when more than 2000 vehicles per hour and per lane pass on working days outside holidays.

3.3 Simulations

As one of the main goals of container transferia is to relieve the port area of road congestion, we estimated the societal impact of transport during peak congestion to gain insight in the problem for transport from the Port of Antwerp to its Belgian hinterland. The analysis was performed in a similar way, as for the evaluation of the LHV introduction. As a benchmark, Figure 12 shows the marginal external cost ratio, comparing direct road transport from the Port of Antwerp to any Belgian municipality in a scenario of free flow traffic to a scenario of direct road transport in structural congestion.²⁸ The marginal external costs for container transport in free flow traffic are in any case lower than the external costs during congestion, but the difference between both scenarios can be spatially different. For the areas depicted in green, the difference between both scenarios is smallest, while the areas depicted in red suffer from the highest (relative) increase in total marginal external costs, when container transport has to be performed during congestion periods. It are thus the areas in red and orange which could benefit a lot from the implementation of a transferium, if the road transport to and from the transferium can be performed outside congestion. It is not a coincidence that these locations are close to the locations suffering from congestion as depicted in Figure 11. The image thus illustrates that substantial societal gains can be achieved by implementing congestion avoiding transport concepts.

²⁸ As input for this analysis, the same methodology as described in section 2.4 was used.

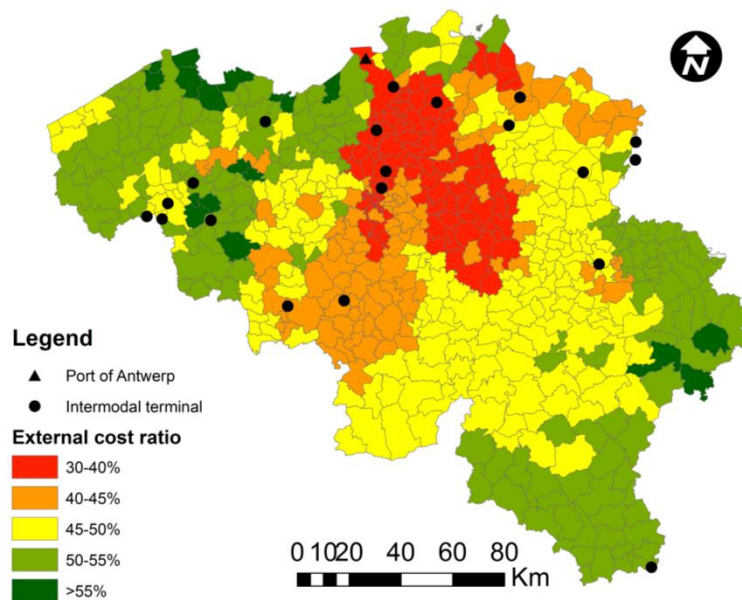


Figure 12 External cost ratio comparing direct road transport outside congestion to direct road transport during congestion²⁹

A second comparison can be made between the external costs of direct road transport and the external costs of barge transport to the transferium in Grobbendonk added up by the required post haul transport by road transport (Figure 13). The left figure suggests that for most of the eastern part of the country, societal gains could be achieved when employing the transferium concept as inland terminal during congestion periods. The areas in green and to a lesser extent the areas in orange are from a societal perspective preferably served by the intermodal alternative. The relative gains, following the external cost ratio, are highest close the transferium and in the direction away from the Port of Antwerp (south-southeast). The figure on the right suggests that these societal gains decrease when all road transport can be performed outside congestion situations.

²⁹ Important to note here is that the lower percentages correspond to the largest relative increase in external costs during congestion periods.

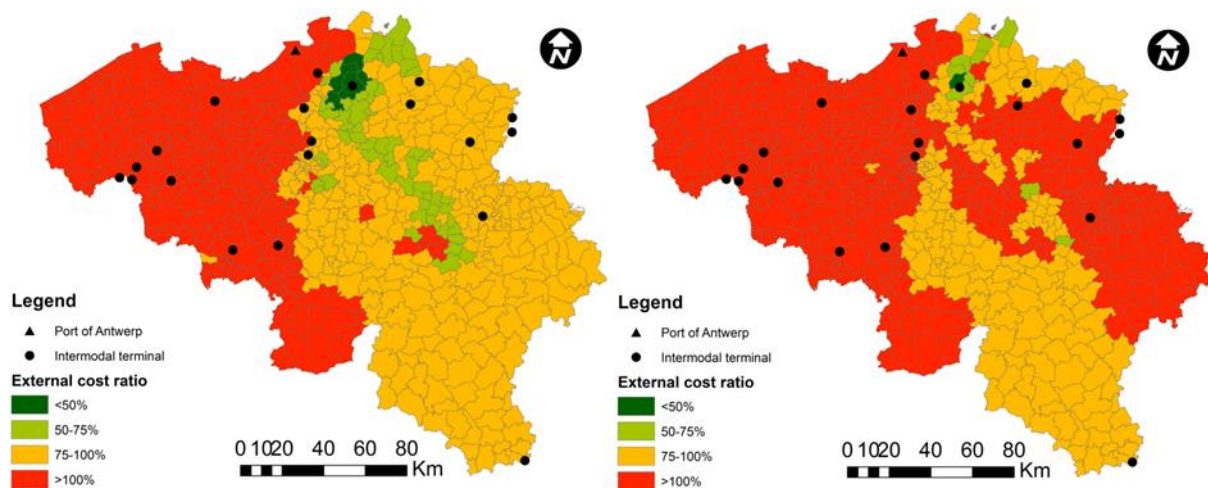


Figure 13 External cost ratio comparing intermodal transport, using the Grobbendonk transferium as transshipment node, during congestion (left) and outside congestion (right) to direct road transport

When comparing the societal impact of intermodal transport using the transferium in Grobbendonk to the societal impact of transport through the cheapest intermodal terminal³⁰, it is obvious that in most cases intermodal transport through the cheapest terminal is a better solution from a societal perspective (Figure 14). The area where the transferium performs better or equally good (green and orange) corresponds roughly to the area where it also is the cheapest intermodal alternative. If the transferium can be used as a transshipment node for barge-barge transport to other terminals, the total external costs will be equal to the ones of intermodal transport, under the assumption that no additional external costs for transshipment operations would occur.³¹ This is in accordance with the findings of Bouchery and Fransoo (2014) stating that the optimal location of a transshipment terminal is located further away from the port, when the aim is to maximize the carbon emission reductions, while it is closer to the port when the aim is to reduce transport costs.³²

³⁰ This is through the terminal offering the cheapest door-to-door chain, as simulated with LAMBIT.

³¹ In practice, the external costs would, however, increase (slightly) due to additional transshipments.

³² This however does not mean that terminals should be located close to the port to optimize the transport costs of the intermodal system. But they should be located closer to the port, than when optimizing the emission-related performance of the network.

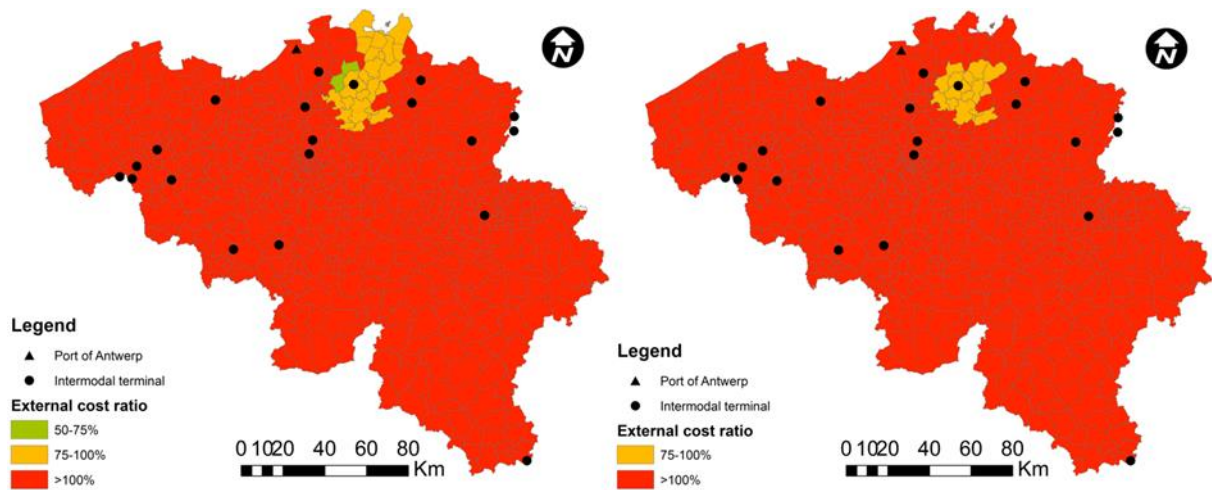


Figure 14 External cost ratio comparing intermodal transport, using the Grobbendonk transferium as transshipment node, during congestion (left) and outside congestion (right) to intermodal transport using the cheapest alternative

Focusing on transport price, the Grobbendonk transferium can only catch a small local market area (see Figure 3 top left) due to its location close to the port. Due to additional economies of scale, this area might, however, be enlarged when its transferium functionalities can bring price reductions. But price levels should be decreased by a rather large extent, if an additional transshipment to another barge is required for the further transport to more remote intermodal terminals. Figure 15 shows the impact of adding a transferium to a regular intermodal chain, focusing on the Limburg region. It appears that only a few municipalities can be served (slightly) cheaper when compared to direct road transport (areas depicted in shades of green).

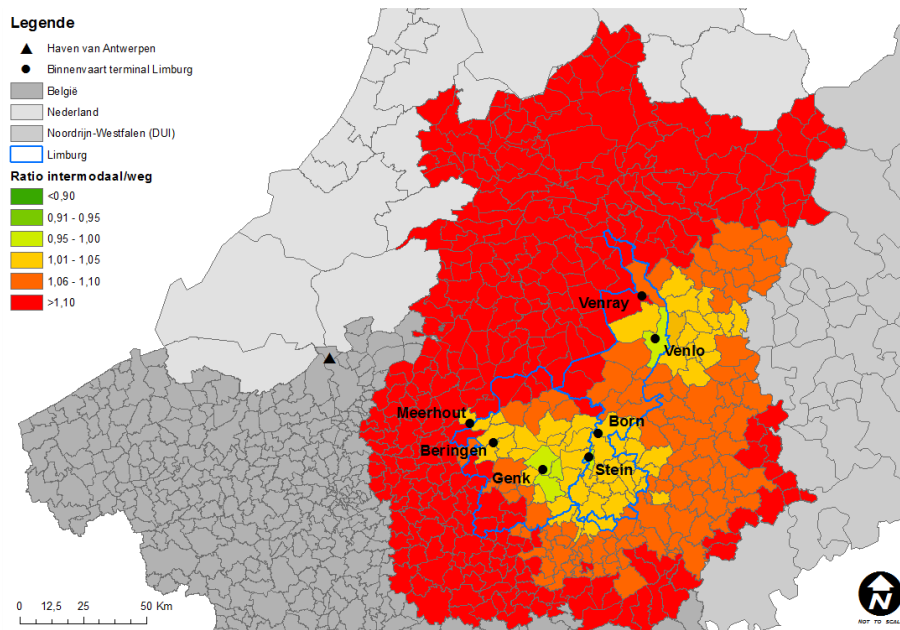


Figure 15 Price ratio comparing intermodal transport, using an additional transshipment in the Grobbendonk transferium to direct road transport to/from the Port of Antwerp, with a focus on the greater Limburg region (Source: Macharis et al. (2014))³³

3.4 Conclusion and outlook

This section discussed the concept of transferia in the Flemish context. In the introduction, we tried to define the concept and to focus on the difference between ‘traditional’ inland terminals and transferia. The main distinguishing features relate to the location of transferia (close to the port) and its functionalities. Next, we described the existing transferium network in the Netherlands and Belgium.

In a third section, we used the LAMBIT model to simulate the societal impact of using a transferium, through external cost simulations. It was shown that especially during congested periods, the use of a transferium can bring substantial societal benefits. Outside congestion periods, the gains are smaller. When comparing the use of a transferium concept to ‘traditional’ intermodal terminals, the latter still causes less societal costs in most cases. Therefore, it can be concluded that a modal shift from road transport to intermodal transport, using the transferium, with the drayage performed by road transport will often bring societal benefits if the destination or origin of the transport does not require a big detour. When transferia are used as additional transshipment locations in an

³³ Only the terminals depicted in the map are included in the simulation.

intermodal chain, its use is however often not competitive for short distance transport operations. This remark is also made by Warffemius and Francke (2010), stating that it is unclear if the market share of inland waterway transport will increase following the implementation of transferia, as transport time and transport time reliability will improve for transport operations using the transferium as hub, when drayage operations can be performed over longer distances outside congestion periods. The cooperation of terminals along strategic axes (such as the Albert Canal), could however increase the potential use of transferia, to decongest the port area.

The analysis above also brings up new questions. First, to what extent will the congestion problem be spatially moved from the port area to the transferium area, when its use is substantially increased? Second, the modal shift issue discussed above can be related to the modal split of ports, terminals, regions etc. When using barge transport between port and transferium, while requiring long distance road transport between transferium and origin/destination, the share of intermodal transport will increase substantially when expressed in the share of intermodal trips. When expressed in the share of ton-km performed by each transport mode, modal split statistics will however only shift slightly towards the more environmentally friendly modes. A recommendation that can be made here, is to clearly state this difference in the modal split statistics of ports and regions, comparing both the share of in/outgoing TEUs by each mode and the share of TEU-km by each mode. A third remark which follows both from this paper and the beleidsnota mentioned above, is the need for an extensive inland terminal classification, not only based on their location, but also on their service offers and their extended network.

4 Modal choice analysis

As a previous policy paper (Meers and Macharis, 2014) already dealt with many relevant aspects in modal choice decision making, this chapter will not deal with a description of the main modal choice criteria, opportunities to decrease transport cost as enabler of a modal shift and the use of modal choice criteria in a multi-criteria setting to enhance a mind shift. This chapter, however, focuses on the importance of modal choice criteria for short distance container transport within Belgium. This information is crucial as input for the three items discussed in the previous paper.

The focus of the European Commission's modal shift policy lays in the long distance transport segment, with the explicit goal to shift 30% of road freight over 300 km to other transport modes by 2030 (European Commission, 2011b). As discussed by Tavasszy and van Meijeren (2011), however, intermodal transport below this 300 km 'threshold' distance exist, as the case of maritime-based transport in Flanders proves and can be successful. In Europe, this <300 km distance segment corresponds to 44% of the ton-km and 89% of the total tons transported. A key to successful short distance services lies in the reduction of transshipment costs and time in combination to sufficient transport volumes (Trip and Bontekoning, 2002).

This chapter addresses the short distance container transport market which – up to now – received limited attention in the modal choice literature (Reis, 2014). In this chapter, we first describe this general setting. The second part focuses on the survey that was conducted to disentangle the modal choice preferences of decision-makers. The third section describes the results of the survey.

4.1 Background

To benchmark service requirements of decision-makers in transport planning, an extensive scientific literature has developed on this topic during the past decades. Crucial aspects discussed in this literature, needing explicit consideration in the set-up of a modal choice experiment are: the identification of influential modal choice attributes, the mode and carrier selection process and the selection of the decision-maker.

The first two aspects: the main modal choice criteria and the available data collection methods, have been discussed in a previous policy paper (Meers and Macharis, 2014). In the experiment described below, the modal choice attributes of price, transit time, transit time reliability and transport frequency were included as main criteria in a choice-based conjoint (CBC) analysis. Nevertheless, also parameters such as shipment size and product characteristics often impact the required service

levels (Feo-Valero et al., 2014). The third aspect is the decision-maker group that is questioned in the experiment. In similar studies, freight forwarders or hauliers and/or companies (retailers, producers, distributors etc.) have been selected as respondents. In this study, it was chosen to include both respondent groups, as mode choice decisions often depend on the shipment size and the interaction between both actor groups (Holguín-Veras et al., 2011).

As mentioned, the focus in this study is on the short distance container transport market. The focus on containers is a consequence of their ‘ease’ to shift to rail and inland waterways transport, together with the ambitions of the Flemish ports to increase the modal share of these modes. Beuthe and Bouffioux (2008) also studied container transport – but as a subgroup – in a Belgian context, and found rather different preferences in comparison to those for the transport of other loading units. Table 4 shows the importance (weight) of the four criteria considered in their study and in this experiment.³⁴

Table 4 Importance of different modal choice criteria (Beuthe and Bouffioux, 2008)

Focus	Weight cost (%)	Weight transport time (%)	Weight reliability (%)	Weight frequency (%)
Container transport	71	10	7	4
Short distance transport	75	4	8	3

The focus on short distance transport, not only follows from the Flemish scale, but also from the fact that most studies focus on the medium- to long distance segments, given the modal shift opportunities in these markets (Reis, 2014). Previous research already showed that transport distance can, indeed, have an important impact on transport service requirements (Rotaris et al., 2012).

³⁴ Other studies (partly) focusing on the Belgian market have been discussed in the previous policy paper.

4.2 The experiment

4.2.1 The set-up

Respondents are required to complete a number of fixed choice tasks, where each task is determined by different concepts. The rationale in this CBC experiment is that decision makers choose the concept that suits their service requirements best.³⁵ The concepts are made up of varying service levels (e.g. Figure 16). The analysis uses the information from the trade-offs that decision-makers have to make to solve the choice tasks. The survey was conducted online, using Sawtooth software.

Transport time	3 h	9 h	6 h	3 h
Transport price	€ 300	€ 325	€ 325	€ 350
Reliability	15%	5%	5%	25%
Frequency	3x per week	1x per day	>1x per day	1x per day

Figure 16 Example of a choice task, including four concepts

As discussed above, four modal choice criteria were included in the CBC experiment. A limited number of criteria (4) and service levels (3 per criterion), allows drawing conclusions from a limited respondents sample, as previous studies already discussed the difficulty in finding sufficient and suitable respondents. Transport modes were not explicitly considered, as other mode-related characteristics can influence the choice among the concepts. The considered criteria were defined as:

- **Transport price:** the transport price of a door-to-door transport of one container, including loading and unloading
- **Transport time:** the transit time of a transport, starting from loading until unloading, including waiting times
- **Transport reliability:** the share of transports where the pick-up/delivery does not take place within the demanded time window (to late/to early)³⁶

³⁵ This is the concept that maximizes their utility.

³⁶ Reliability was included in the experiment, after testing the CBC, as the share of shipments arriving outside the expected time window, corresponding to the notion of unreliability instead of reliability.

- **Transport frequency:** number of possibilities to organize the transport service (per day/week)

Aiming to achieve a balance between statistical efficiency and the burden for respondents to participate, 8 choice tasks were sent to each respondent. As the number of concepts (4) was greater than the number of service levels per criterion (3) overlap in service levels was achieved, requiring trade-offs in each choice task. In this way, choosing for a single service level (e.g. a 3 h transport time) in each task without considering trade-offs was not possible in all choice tasks. The experiment included one fixed choice task that had to be filled out by each respondent.

To calculate the overall preferences of the decision-makers, the hierarchical Bayes (HB) approach was chosen, as advocated by Lebeau et al. (2012). Utilities are estimated with HB and rescaled after the analysis, to compare the utilities of different attribute levels.

4.2.2 The respondents sample

A broad group of respondents was targeted in this experiment, including transport operators, logistics service providers (LSPs), shippers and shipping agents. The main group of targeted respondents, however, was the shippers. If possible, transport planners or the logistics- or general managers were directly contacted by email or phone.

Three types of respondent sampling were used to contact sufficient respondents. First, a shipping agent's federation and a shippers' association sent out the link to the online survey to their members. Second, a LinkedIn search was performed, using transport/logistics manager/planner as search terms and/or Logistics group memberships to reach additional respondents. Third, contacts of the research groups were contacted and snowball sampling was used to extend the sample. In total, approximately 656 companies were contacted, of which 148 people accessed the online survey. The answers of only 50 respondents could be used to estimate the preferences³⁷, slightly more could be used to answer some additional questions, discussed in section 4.3.1.

Of the respondents who filled out the CBC experiment, 21% worked in a transportation company or as a LSP, 6% as a shipping agent and 74% as a shipper. Regarding the number of employees, 68% of these companies had more than 100 employees, 19% between 11 and 100 and only 6% 10 or less, with 8% providing no information. Of the transport companies and LSPs, 73% owned a fleet of which

³⁷ Some respondents did not fill out the survey completely; others did not use container transport etc.

88% had road transport vehicles and 25% inland waterway transport (IWW) means. Of the shippers, 13% owned a fleet, of which all had road transport means and 20% IWW transport means.

4.3 Results

4.3.1 Modal shift barriers

To gain broader insight in the respondent’s choice behaviour, additional questions were included in the survey. The majority of the respondents indicated to use road transport for the majority of their trips (Figure 17). A minority of respondents (10%) used one of the three intermodal alternatives for at least 50% of their transport operations. 51% of all respondents mentioned to use an intermodal alternative for some transport operations, while 75% did not solely use road transport.³⁸

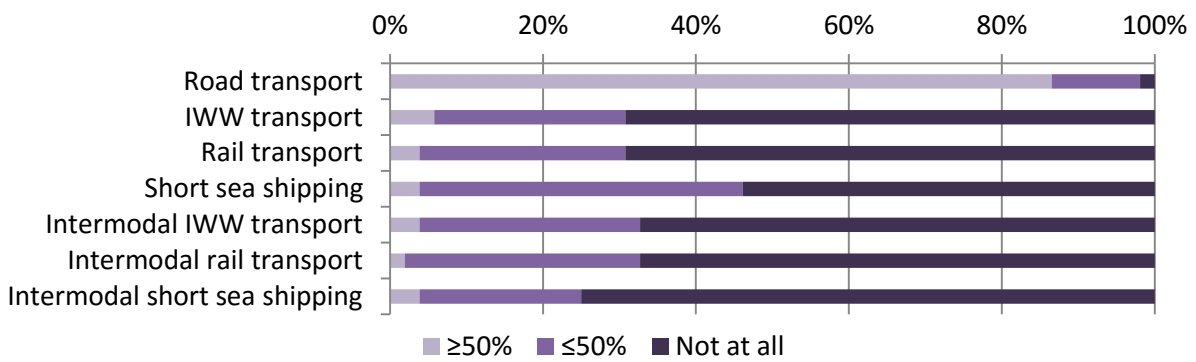


Figure 17 Transport options deployed by the respondents’ companies.³⁹

Of the respondents that are currently not using (any) intermodal transport solutions, 42% never considered using intermodal transport alternatives (Figure 18). Despite the efforts done to enhance a modal shift, many companies never considered using intermodal, leaving potential for additional modal shift (awareness) programs.

³⁸ This latter group also includes respondents that use unimodal rail-, unimodal inland waterways-, or unimodal short sea shipping transport.

³⁹ IWW stands for inland waterways

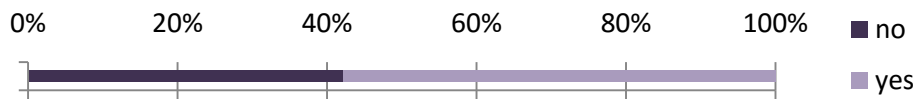


Figure 18 Share of respondents not using intermodal transport that considered using it (yes) and that never considered using it (no)

Another part of the questionnaire focused on reasons why respondents are currently not, or to a lesser extent, using intermodal transport services. Figure 19 indicates the main reasons given by shippers and LSPs.⁴⁰ Shippers indicate five important reasons, being too slow, poor service offers, uncertainty on flexibility, insufficient frequency and unreliability. Operators and LSPs mainly blame the lack of frequency, the transport speed and the lack of service offer. One nevertheless has to be aware, that intermodal transport cannot outperform direct road transport on all these aspects. Around 15% of the shippers in the sample also indicated that information on the intermodal solutions is lacking.

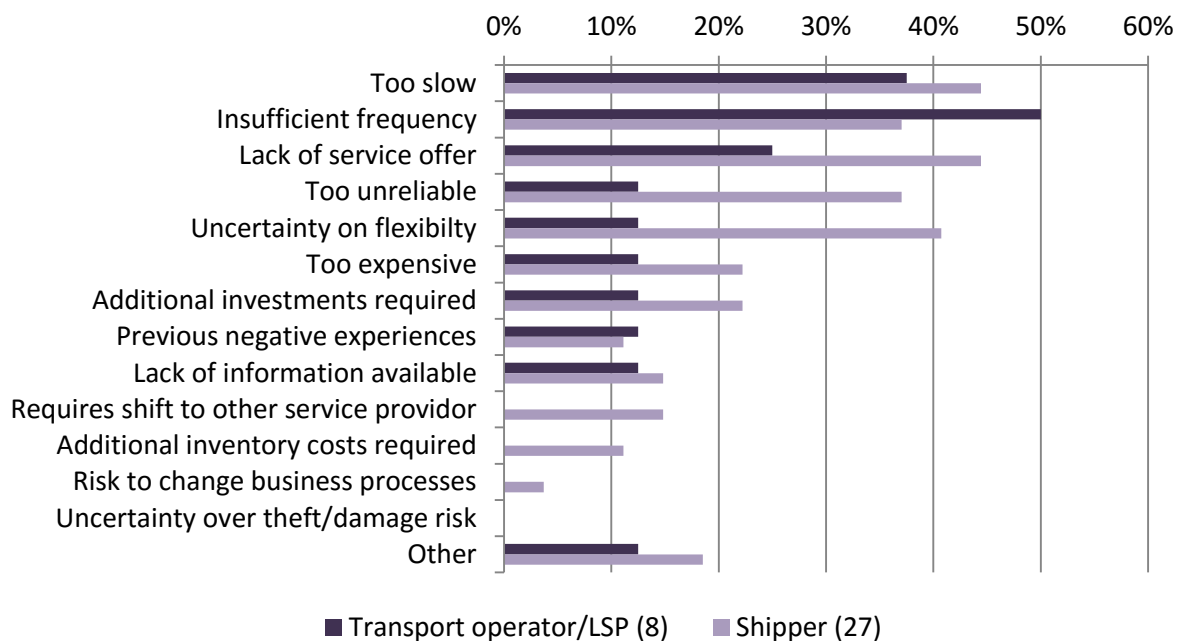


Figure 19 Reasons for not – or to a lesser extent – using intermodal transport services.

The last questions in the questionnaire focused on who is involved in the mode and route decision making. Regarding the mode choice (Figure 20), the shipper seems the most dominant actor,

⁴⁰ As only two shipping agents completed this part of the questionnaire, they were not included in the graph.

although only around 55% of the LSPs says the shippers is the actual decision-maker. The figure illustrates that according to both actor groups; shippers are more often involved in this decision, than LSPs and shipping agents. A similar question focused on the aspect of route choice (Figure 21). Both actor groups indicate a similar share to the operators/LSPs. The decision power the shippers award themselves is however, much higher than the share they are awarded by the operators/LSPs. A part of this difference can be explained by the fact that some shippers own a fleet and organize (part of) their transport without an LSP or shipping agent.

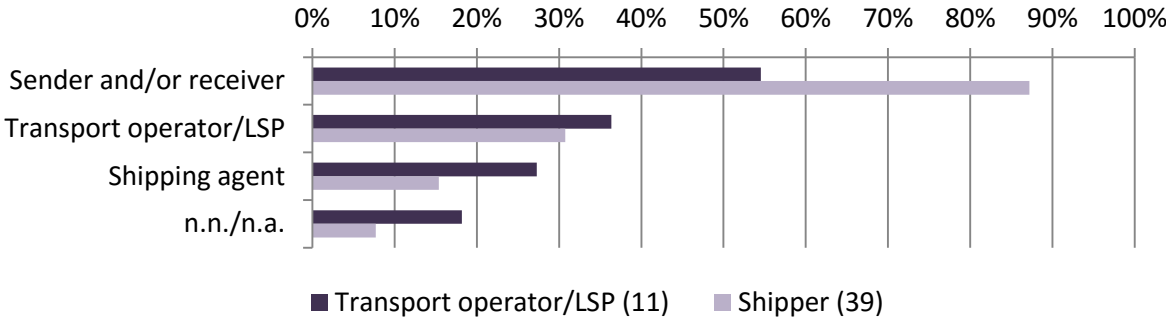


Figure 20 Actors involved in the modal choice decision making according to the respondents.⁴¹

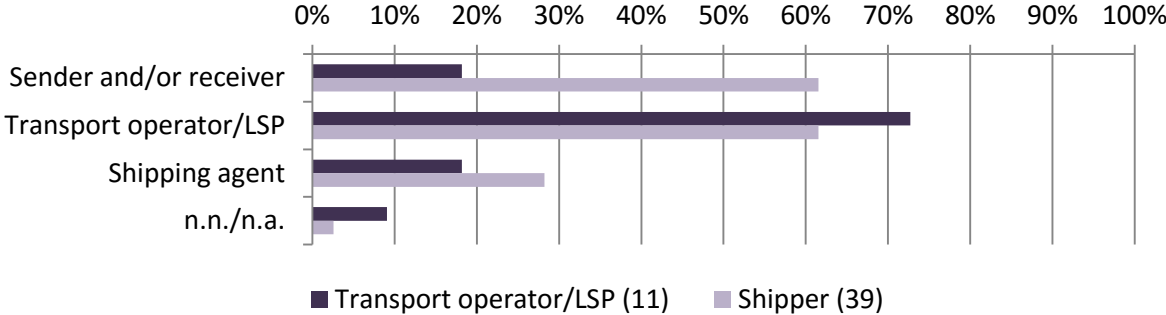


Figure 21 Actors involved in the route choice decision making according to the respondents.

4.3.2 Preferences

Focusing on all random choice tasks, each of the concepts (1, 2, 3 and 4) was chosen an equal number of times (23.5-25.9%). This indicates that all concepts were considered by the respondents.

⁴¹ N.n. indicates that the respondent did not know which actors were involved, n.a. indicates that the question was not applicable to the respondent.

Next, utilities (indicating the preference for a specific attribute) were calculated.⁴² The model estimation, however, showed that the attribute relating to reliability was incorrectly interpreted by a part of the respondents. The other attributes were estimated in a consistent way. Both the percent certainty, giving an indication of how much better a solution is than chance, and the root likelihood (RLH) level, which measures the goodness of fit, were however acceptable (simulation A in Table 6).

A part of the respondents that misinterpreted reliability could be identified through a thorough analysis of the surveys and by using a control question, which questioned the respondents on their minimum required service level, as a cross-check. Next, also ‘wrong answers’ could be identified, as respondents could chose for concepts that were in no case interesting options, unless the reliability attribute was misinterpreted. Because the surveys were not conducted face-to-face, these errors could only be discovered during the post-processing. To overcome the previously described problem, it was decided to split the respondents in three groups (B1-B3) (see table 6). This obviously led to better results for groups B1 and B2, comparing to group A.⁴³

Table 5 Simulations’ characteristics.

Simulation	# respondents	Percent certainty	RLH
A: all respondents	50	0.762	0.720
B1: misinterpretation of reliability	19	0.830	0.791
B2: correct interpretation of reliability	18	0.819	0.779
B3: uncertain interpretation of reliability	13	0.728	0.686

RLH= Root Likelihood

When simulating the utilities for the other three attributes for the B1-B3 subgroups, similar values were obtained (Figure 22). An unexpected finding was that the utilities of price and time were of the

⁴² Hierarchical Bayes (HB) was used to estimate these utilities. A more elaborated description of this methodology can be found in the upcoming conference paper ‘Modal choice in short-distance hinterland container transport’ (Meers et al., 2016).

⁴³ Even though the number of respondents decreased in simulations B1 and B2, the percent certainty and the RLH increased.

same magnitude.⁴⁴ This shows that transport speed is an important attribute for at least a part of the sample. This can be linked to the burden for using intermodal transport, for being 'too slow' (Figure 19).

The interest for transport time could be (partly) explained by the focus on short distance transport, as was already discussed by Rotaris et al. (2012), although this assumption should be investigated in future work. Some companies can indeed be located close the port, to decrease transport times and benefit from fast deliveries.

The utility values of frequency indicate that a daily frequency is clearly preferred over a frequency of 3 departures per week. More interesting is that the utility of a higher frequency (in se: multiple transports per day) is not higher than the utility of a daily service. This indicates that one departure/arrival per day seems to be sufficient for many companies.

The fact that reliability was interpreted in a wrong way by many respondents makes it difficult to draw strong conclusions. Nevertheless, 68% of the respondents indicated that they would not accept all presented reliability service levels.⁴⁵ For transport time only 20% reported unacceptable levels, for transport price 26% and for frequency 34%. Therefore, it can be concluded that the sample of decision-makers has heterogeneous preferences.

As recommendations for the intermodal sector, it seems that price remains an important variable, but that also qualitative service levels are important in modal choice decisions. Increasing intermodal services up to a daily frequency (where this is not yet the case) could be a good initiative. Fewer gains can be made when focusing on transport time, as both barge and rail cannot compete to road transport, partly as a consequence of the (un)loading - and waiting times. Therefore it makes more sense to focus on promoting the short transport time for pick-up and delivery to/from the intermodal terminal. The analysis also shows that more than one departure per day is not required, when discussing the overall preferences of decision-makers. Therefore, the focus can shift to providing reliable transport services.

⁴⁴ Important here is that the utilities should be interpreted in a relative way, which means that it is not the preference for an attribute which is compared but the preference for an attribute level.

⁴⁵ For the ones who misinterpreted reliability, it is however difficult to know how they did interpret the presented reliability attribute levels.

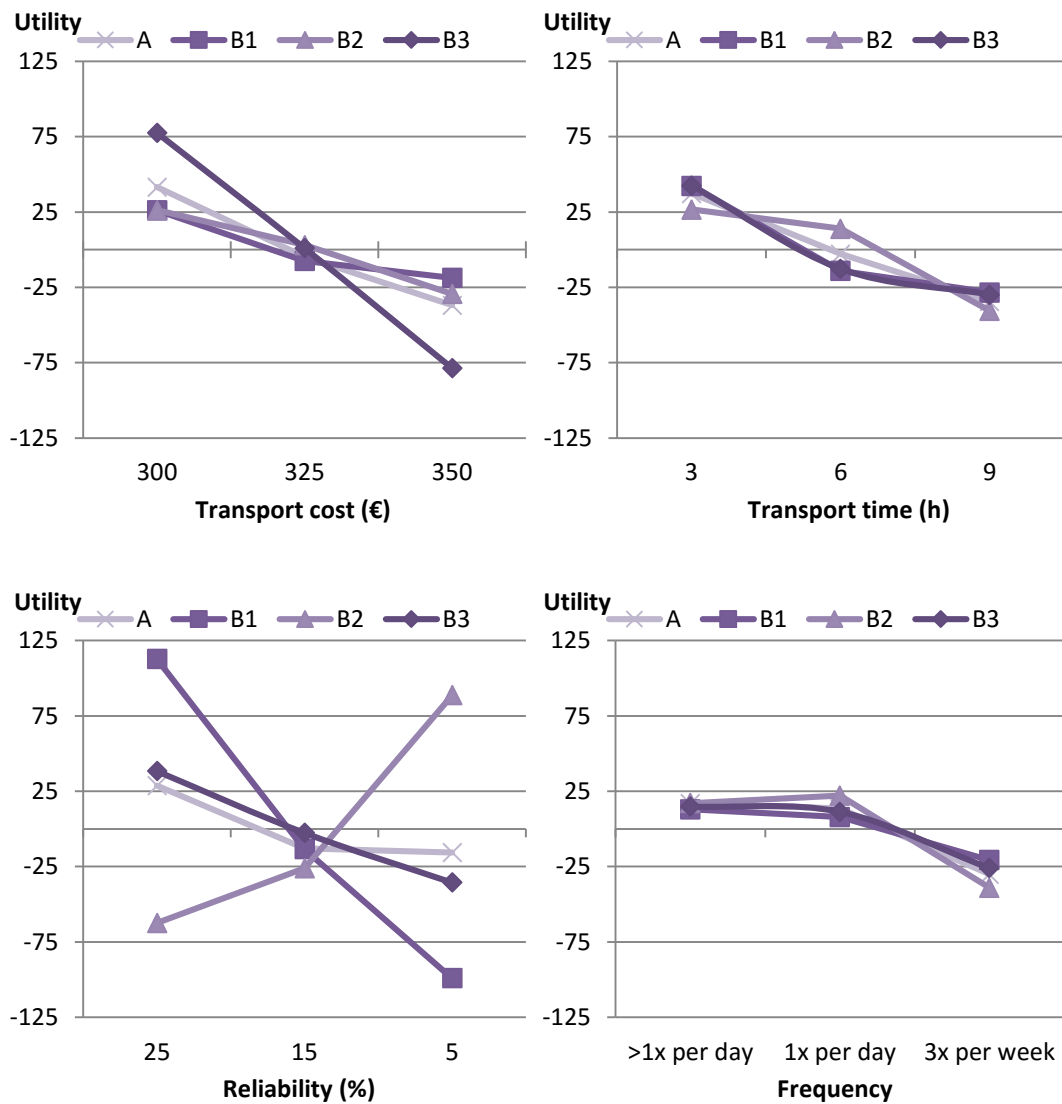


Figure 22 Utilities of the four attributes in the four simulations.

4.4 Conclusion and outlook

This chapter discussed a choice experiment conducted among shippers, logistics service providers and transport operators on the evaluation of modal choice criteria in the case of domestic container transport in Belgium. The modal choice criteria of transport price, transport time, reliability and frequency were analysed. Unfortunately, a share of the respondents misinterpreted the reliability attribute, reducing the potential insight that could be gained in this modal choice criterion.

From the analysis can be concluded, however, that price is, considering the attribute level of the experiment, less dominant in modal choice decisions than expected. Besides competitive prices, a

daily frequency and acceptable reliability levels are important factors to further enhance a modal shift, as currently insufficient frequency levels and long transport times limit the use of intermodal transport in Flanders. Notwithstanding, price remains an important factor in decision making, which should not be neglected, as more than 20% of the shippers questioned indicate that price is currently a barrier for (increasingly) using intermodal transport. The earlier analyses, however, suggest that the price ratio between unimodal and intermodal transport is very location dependent. For transport to locations close to terminals can in general lower prices be offered by intermodal operators compared to the road-only alternatives.

Another finding from the questionnaire is that an important share of decision-makers does not have access to the right information to consider a modal shift. Even more striking is that more than 40% of the respondents that indicate not to use intermodal transport, never even considered using it.

5 Conclusion and outlook

This paper addresses how the intermodal transport market in Flanders should look like in the future. Three aspects of the transport market were considered in this paper, being the transport supply (infrastructure and vehicles) and the transport demand. Three cases were elaborated: the first focusing on the possible introduction of LHVs in Flanders, the second evaluating the transferium concept and the third evaluating different model choice criteria.

The analyses indicate that LHVs can be an interesting alternative to regular trucks, when considering both the cost of road transport and the externalities caused by both transport means, under the condition that the accident risk does not increase. There is little evidence of a far-reaching reverse modal shift, from intermodal transport to LHVs, in foreign cases where LHV transport is allowed. Although, there has been little research dealing with the ex-ante evaluation of the phenomena. The simulations in this paper indicate that price reductions in road transport, following the use of LHVs, can have a big (spatial) impact on the competitiveness of intermodal transport services. Although, the potential market for LHV transport use needs to be clearly demarcated to translate this risk into the identification of the transport flows 'under risk'. When considering external transport costs, LHVs can outperform regular trucks, but for most transport flows, the intermodal alternatives still perform better. A reverse modal shift therefore has to be discouraged. In particular in the regions where intermodal transport is price-competitive, a reverse modal shift should be avoided from a societal perspective.

Transferia distinguish themselves from other intermodal terminals mainly by their location (close to the port) and to a lesser extent by their functions (i.e. possible barge/barge transshipment hub). The use of the concept is however ambiguous and different authors classify different Belgian terminals as transferia. Transferia can help in decongesting the port area, but their contribution to decreasing the total external effects of a transport chain depends strongly on the market that is served by the transferium and on the organization of the transport from the transferium to the final destination. The analyses show that when an additional transshipment is required, transport on short distances is in few cases a price competitive solution. The dual role that can be performed by transferia can also severely impact modal split statistics of a regions, country, port etc. Therefore it is important to clearly indicate whether the modal shares are expressed in ton (or TEU), ton-km (or TEU-km), share of departures etc. The difference between ton and ton-km for instance will become apparent when drayage distances vary strongly.

The third part of this policy paper focused on modal choice behavior for short distance container transport within Belgium. A choice-based experiment was set up to estimate the importance of four major modal choice criteria, being price, time, reliability and frequency. The results of the experiment show that there are still opportunities to enhance a modal shift, initiated by bottom-up initiatives such as modal shift analyses of specialized consultants or by the setup of (online) information campaigns, as an important share of non-users of intermodal transport never even considered to use intermodal solutions. A smaller share of the respondents also indicated not having good access to the required information to consider a modal shift. The experiment also showed that the importance of price is somewhat smaller than expected in modal choice decisions and that at least a part of the respondents indicated that a rapid delivery is important to them.⁴⁶ Frequency is considered important, but one departure per day seems to be sufficient for many respondents. Regarding the criterion of reliability, defined as the share of shipments arriving outside the expected time window, the largest share of respondents indicated to have minimum service requirements.

An interesting avenue for further research finally, relates to the concept of synchronodal transport which gained ground, especially in the Netherlands, during the past years (Tavasszy et al., 2010). The scientific and business interest in the topic has increased strongly and requires an investigation in the needs and opportunities in Flanders.

⁴⁶ The LAMBIT simulations however suggest that the price ratio between road-only transport and intermodal transport is strongly location dependent. In 'remote' locations, price can thus be still an important barrier to the use of intermodal transport.

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7 Appendix

7.1 Technical external cost calculations

The following technical description of the calculation of external transport costs was taken from the research paper of Meers et al. (2015).⁴⁷

As the LAMBIT model uses the existing transport networks to calculate routes, external cost information is linked to each transport network segment. These segments are classified on inter alia the allowed speed. To account for population densities, network segments were linked to the population densities of the municipalities they are located in. Higher population densities mean that more people can be impacted by for instance particle matter. Information on population densities was derived from STATBEL (2014). The types of vehicles considered are regular trucks and LHV's, electric and diesel trains with lengths based on a survey and four types of barges: the Kempenaar-Campinois, the Dortmund-Ems-Canal barge, the Rhine-Herne-Canal barge and the Big Rhine barge.

Next, the different marginal external cost values, derived from different sources, are linked to the corresponding network segments in the LAMBIT model. The external cost input figures are derived from the study of Gibson et al. (2014), which provides country-specific damage costs for most external costs included in this study. If not mentioned differently, the assumptions made in van Lier et al. (2015) are made. One of the main assumptions was that load and weight of the containers (average), the average utilization of TEU capacity and the share of loaded containers from the Gibson et al. (2014) study could be used. The container unit capacities were as much as possible derived from transport operators. The prices mentioned in the simulations are expressed in 2010 equivalents.

7.1.1 Emissions

Four types of transport emissions were included in this analysis, namely: CO₂, SO₂, NO_x and PM_{2.5}. These are all included in the study of Gibson et al. (2014), and damage costs are derived from the same study, while the emissions factors used are derived from the STREAM update study (den Boer et al., 2011). In LAMBIT, the emissions are differentiated by (road transport) congestion level (2 scenarios considered), road (speed limit) type and population density.

⁴⁷ Meers, D., van Lier, T., Macharis, C. 2015. Longer and heavier vehicles in Belgium: a threat for the intermodal sector?, *Submitted to Transportation Research Part D*.

Inland waterways emissions were differentiated by vessel type and according to the CEMT (European Conference of Ministers of Transport) classification of the corresponding waterways. Relevant data was derived from the study of van Lier and Macharis (2014) for Waterwegen en Zeekanaal NV. It was assumed that these Flemish values are representative for the whole of Belgium.

Emissions of diesel trains are also based on the data from the Gibson et al. (2014) study. For each intermodal train, the capacity limits were taken into account. Electric trains have no operational emissions and because up- and downstream emissions were not included in the scope of the study, their emissions were set at 0, irrespective of train length and loading degree.

7.1.2 Accidents

De Vlieger et al. (2004) provided input values for the calculation of the marginal external accident costs, while den Boer et al. (2011) provided input for the rail transport accident values. Again, Gibson et al. (2014) provided values for road transport. As no specific values for LHV's are available, it was assumed that there is no increased safety risk, compared to transport with regular trucks. This implies that safety preconditions should be met on the whole transport network that is used by LHV's. The study from Brijs et al. (2007) indicates that this assumption can be made if these preconditions are fulfilled.

7.1.3 Noise

For noise costs, Gibson et al. (2014) provide input values, differentiated by the population density, for road and rail transport. These values are however expressed in the number of people per transport network km. This study, however, assumed that the division of population densities per km² could also be used in this case. Following van Lier et al. (2015), the assumption is made that LHV's do not generate additional marginal noise costs, when compared to regular trucks. Following Maibach et al. (2008), marginal noise costs for inland waterway transport were set to zero.

7.1.4 Infrastructure

For road transport, again, marginal external infrastructure costs values were derived from Gibson et al. (2014). Based on the categories included in this report, estimates for Belgium were made on the number of axles of a truck. The marginal infrastructure costs for inland waterway and rail transport were also derived from Gibson et al. (2014).

7.1.5 Congestion

For road transport, marginal external congestion cost values were derived from Gibson et al. (2014). A differentiation in population sizes, road types and congestion levels was made. The data from the report were converted, in order to have population densities on municipal level. An additional differentiation on the road network types was made, based on the maximum speed allowances. Values for LHVs, were calculated using a conversion value from Gibson et al. (2014). This study focuses on two scenarios, one with road congestion and one with free flow traffic on most of the network. Locations with heavy congestion were identified based on the report of the Flemish Traffic Centre (2013) and included in the GIS analyses.

No marginal external congestion costs for inland waterway transport were included, following Gibson et al. (2014). For rail transport, specific values for Belgium were derived from the Marco Polo calculator (Brons and Christidis, 2013).

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