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A decision analysis framework for intermodal transport: Comparing fuel price increases and the internalisation of external costs

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ABSTRACT

This paper presents the impact of fuel price increases on the market area of intermodal transport terminals. Aim of this research is to determine whether an increase in fuel prices is sufficient enough to raise the market area of intermodal transport to the same degree that would be accomplished by stimulating intermodal transport through policy instruments. Therefore, several fuel price scenarios are analysed in order to verify the impact of different fuel price evolutions on the market area of unimodal road transport compared to intermodal transport in Belgium. The LAMBIT-model (Location Analysis for Belgian Intermodal Terminals), which is a GIS-based model (Macharis and Pekin, 2008), is used to analyse the different fuel price increases and enables a visualisation of the impact on the market area. The LAMBIT model incorporates the different network layers for each transport mode by setting up a GIS network that includes four different layers: the road network, the rail network, the inland waterways network and the final haulage network. The geographic locations of the intermodal terminals and the port of Antwerp are added as nodes in the network and the Belgian municipality centres are defined and connected to the different network layers. Based on the different fuel price scenarios representing respectively a fuel price increase with 10% (low price case), 50% (business as usual case) and 90% (high price case), the results of the LAMBIT model show that the market areas rise in favour of intermodal barge/road and intermodal rail/road. Depending on the scenario, the degree of modal shift however differs. Additionally, in order to compare policy measures with the effect of a fuel price increase, the internalisation of the external costs is analysed with the LAMBIT model. For some years, the European Commission is supporting the idea that transportation costs should reflect the true impacts on environment and society, and is relentlessly pushing towards the so called 'internalisation of external costs' as a policy instrument in order to establish fair and efficient pricing of different transport modes. This requires monetarizing the external effects of transport and adding them to the already internalized costs in order to give the correct price signals. Results of this comparative analysis performed with the LAMBIT model are also presented in this paper.

1. Introduction

In general there is an unequal growth in the different modes of transport within the EU. Compared to other European countries the modal share of road transport is higher in Belgium than in the Netherlands, Austria and Germany but lower than the EU-27. The increasing importance of door-to-door and just-in-time services has led to a strong sustained growth

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of road transport (European Commission, 2006). The modal share of rail transport is very small for the EU-27 and this is also the case for Belgium, where 78.18% of goods is transported via road, while rail transport accounts for only 10.29% and inland waterways for 11.53% (Universiteit Antwerpen, 2008). The European Commission has developed policy measures to shift the balance between transport modes with special focus on promoting intermodal transport. The political and scientific interest in intermodal transport has grown significantly in the last three decades. This type of transport has been strongly advocated because of environmental concerns, reasons of overall efficiency and the benefits of co-ordination of modes to cope with growing transport flows (Bontekoning et al., 2004).

In Belgium, federal and regional governments have also introduced measures in order to stimulate the intermodal transport market even on short distances. Various combinations of policy instruments can be formulated along the intermodal transport chain. Firstly, Member States can formulate *subsidy schemes* in order to promote the growth of intermodal transport and this is one of the most common policy measure in this area (Macharis et al., 2008). Secondly, *internalisation of external costs* leads to a more efficient use of transport infrastructure (Macharis et al., 2010). In Ricci and Black (2005) the social costs of intermodal transport are measured, thus focussing on both the private and external costs. The authors conclude that full internalisation of external costs will benefit intermodal transport. Kreutzberger et al. (2003) state that the environmental performance of intermodal transport is substantially better than that of unimodal road transport when looking at energy use and CO_2 emissions and this is even more outspoken when also local emissions, accidents, congestion and noise are integrated. The authors conclude that the political and scientific interest in intermodal transport is largely due to the sustainability and ecological aspect of this transport mode.

The aim of this paper is to determine whether an increase in fuel prices is sufficient enough to raise the market area of intermodal transport to the same degree that would be accomplished by stimulating intermodal transport through policy instruments. In order to compare policy measures, the internalisation of external costs is chosen as it is, due to the repeatedly announced ambition of the European Commission to implement it in the (near) future, a highly relevant and well-studied instrument in a transport context. Focus in this paper will be on containerised transport. When looking at containerised transportation, the major factors that determine its attractiveness are related to transportation costs, time in transit and reliability of transit time. This paper focuses on the transportation costs, which are mainly determined by fuel prices, the efficiency of the transportation mode and taxes. The main research question of this paper is to determine whether intermodal transport can be stimulated through an increase in this fuel price so that no or less policy measures have to be integrated.

In order to verify the effect of an increase in fuel price on the market area of intermodal transport several price scenarios will be analysed. Therefore the LAMBIT-model (Location Analysis for Belgian Intermodal Terminals), which is a geographic information system (GIS)-based model (developed by Macharis, 2000), is used. The LAMBIT-model makes it possible to analyse the different fuel price increases and evaluate the impact of different policy measures on the market area of intermodal transport.

In Section 2 the impact of fuel prices on the price of intermodal and road transport is given. Section 3 shows the methodology and the results of the LAMBIT-model. Finally conclusions are drawn and future research perspectives are presented in Section 4.

2. Impact of fuel price on the price of both intermodal and road transport

The general framework of freight transport consists of different activities that represent both internal and external costs. Internal costs are those incurred by a transport operator and contain different components such as personnel, fixed assets, energy, stock return, time, organisation costs and insurance, taxes and charges (Ricci and Black, 2005). For our analysis, focus will be on the energy costs part of internal costs because of the relevance to the subject. In the second and third subsections, the break-even distance and internalisation of external costs are introduced.

2.1. Energy cost framework

The energy costs are connected to the retail fuel price. The fuel price depends on[1]:

– The international Brent price.
– The oil refining costs or import taxes.
– The fuel marketers margins.
– The distribution costs to deliver the refined products to the final customer.
– The national petroleum taxes.

For Belgium, the main direct factors influencing the energy costs are the international Brent price and national petroleum taxes (excise duties and VAT). The retail fuel price consists for 30–40% of excise duties and energy contribution.[2] The excise duties are set by the federal government and are not affected by a change in the Brent price. Below the main factors are described.

[1] PETROLFED.
[2] Ibidem.

Table 1
Effect of an increase in retail fuel price according to three scenarios. Source: VUB, MOSI-T.

	Scenario 1 low price case	Scenario 2 business as usual case	Scenario 3 high price case
Crude oil price ($/barrel)	50$	130$	200$
Increase versus current price	↑ 30%	↑ 160%	↑ 300%
Increase in diesel price	↑ 10%	↑ 50%	↑ 90%

2.1.1. Brent price

In 2008, oil and diesel fuel prices reached historical records but due to the weak dollar, the impact on the diesel price was partially dampened. The financial crisis had a significant lowering effect on the diesel fuel and oil prices since the recession caused demand for energy to shrink and prices plunged as well, but this effect was considered temporary due to the projected long-term upward trend in international oil prices (NBB, 2009).

The EIA (Energy Information Administration, 2009) developed forecasts to predict the future oil prices. In their Annual Energy Outlook 2009 three different scenarios for the Brent price were described, namely a low price case, a business as usual case and a high price case. The forecast for 2030 expressed in $/barrel was converted to the diesel price in Belgium and takes into account that the crude oil price effects the retail fuel price for 40%.[3] This $/barrel assumptions had to be converted in euro and therefore an exchange rate between dollar and euro was set at 1,1 in accordance with the forecasts of EIA and Petrolfed. Table 1 shows the effect of increases in the retail fuel price according to three scenarios forecasted by the EIA (2009).

2.1.2. National petroleum taxes

On January 6th of 2010 nearly 35% of the fuel price (excl. VAT) and 53% of the fuel price (incl. VAT) consisted of excise duties and energy contributions. Furthermore the retail fuel price is subject to a VAT of 21%. A change in Brent price affects the retail fuel price for 40%.[4]

The diesel tax levels for rail transport are lower than for road transport in France and in the Netherlands. For Belgium the diesel tax for road transport amounts to 0.362€,[5] while for rail transport no diesel tax is charged according to Infrabel. In Belgium inland shipping is also exempted of fuel duties (NEA, 2008).

2.1.3. Price of electricity

According to the European Commission (2008) 84% of the Belgian railway network (including freight and passenger transport) was electrified in 2005. According to B-Cargo (Footnote 1) 30% of the rail cargo locomotives transport goods via diesel traction (figures for both national and international rail transport).

Fig. 1 compares the price of crude oil with the price of electricity in Belgium. The figure clearly shows that the price of electricity is less volatile then the price of the crude oil. The oil price increase in 1999–2000 had no impact on the price of electricity. During the crude oil price increase in 2005 the price of electricity rose but to a much smaller degree. An outspoken increase of the Brent price will have only a small effect on the cost of power source for rail transport. The price of electricity is also determined by other factors for example the liberalisation of the energy market, the internalisation of the external costs of electricity, etc. (Ecorys, 2006). There is no electricity tax for rail transport in Belgium according to Infrabel.

2.2. Break-even analysis

In transport practice intermodal transport is considered as an alternative to unimodal road transport from a certain distance, called 'break-even distance' (Vrenken et al., 2008). Intermodal transport's advantage is its scale, but this advantage only counts when the costs of transhipment and terminal cartage have been offset, making intermodal transport a competing mode once the 'break-even distance' is reached.

A fuel price increase affects the variable cost of both unimodal and intermodal transport. Fig. 2 visualises the impact on the break-even analysis. Intermodal transport becomes more competitive but this is tempered to some degree as the cost of initial and end road haulage also rises. In Section 3 the effect on the break-even distance will be calculated with the LAMBIT-model.

2.3. External cost framework

In the previous section the effect of the fuel price on the price of intermodal and road transport was described. In order to be able to compare the effect of a fuel price increase with the effect of a policy measure on the modal share of intermodal and

[3] PETROLFED.
[4] Ibidem.
[5] Ibidem.

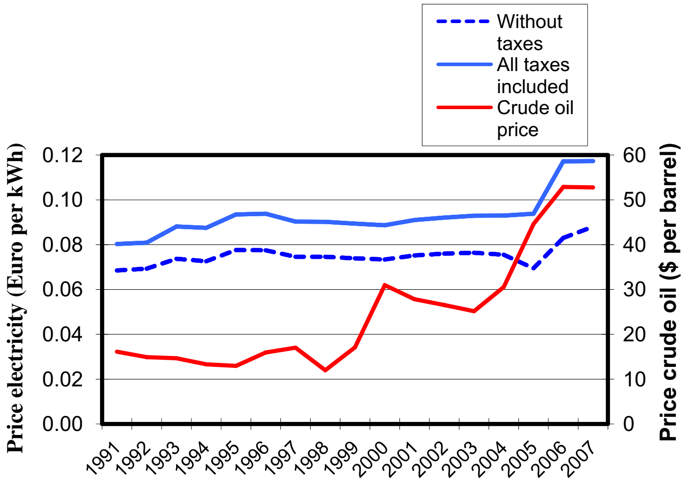


Fig. 1. Price of electricity compared to price of crude oil. Source: Eurostat, ECB.

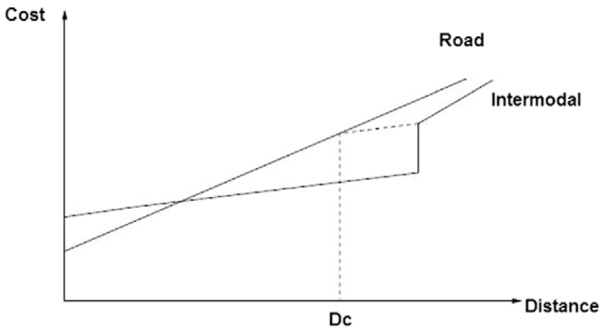


Fig. 2. Break-even analysis between road and intermodal transport. Source: Macharis and Verbeke (2004).

unimodal transport, it was decided to look at the policy measure of internalisation of external costs. In the following section the concept of externalities, external costs and internalisation of these costs are briefly presented.

Externalities are changes in welfare caused by economic activities without these changes being reflected in market prices (Weinreich et al., 1998). In the field of transport these externalities arise when transport consumers/producers impose additional costs on society without having to bear these costs themselves. External costs are externalities expressed in monetary terms.

In the literature, the most important external costs of transport are the following ones (Infras/IWW, 2004):

- Accidents.
- Noise.
- Air pollution.
- Climate change.
- Congestion.

Regarding the external costs of road transport, an important distinction is made between "intra-sectoral externalities" and "inter-sectoral externalities" (Verhoef, 2000). Intra-sectoral externalities are, like congestion and part of the external accident costs, imposed upon one another by road users. Inter-sectoral externalities are, like environmental externalities, noise annoyance and another part of the external accident costs, imposed upon society at large. It is sometimes argued that intra-sectoral externalities such as congestion are not an externality since it is almost entirely internal to the road transport sector. As however Verhoef (2000) states, for a correct welfare analysis, the relevant level of disaggregation is the individual level, so that at least from a welfare economic point of view both intra-sectoral and inter-sectoral externalities are Pareto-relevant.

Calculation of the relevant external costs in this specific case is based on the best practices in the field of marginal external cost assessment currently available in scientific literature.[6] Although there is growing consensus on the main methodological issues (Maibach et al., 2008), there remain many uncertainties when performing an external cost assessment in practice.[7] Numerous studies have shown that marginal external costs of transport activities depend strongly on parameters such as fuel type, location (urban, inter-urban, rural), driving conditions (peak, off-peak, night) and vehicle characteristics (EURO standards) (Panis and Mayeres, 2006). As a result, the external cost of one truck-kilometer in urban areas during peak traffic can be up to five times higher than the cost of an off-peak inter-urban kilometer of the same vehicle (Maibach et al., 2008).

Distinction should be made between short and long run marginal costs. Short run marginal costs are related to an additional vehicle entering the (existing) system and consider only variable costs (i.e. costs depending on traffic volume), neglecting fixed costs to run the system or additional costs for possible network improvements in the longer run. Long run marginal costs are considering future system enlargements due to increased traffic volume. Since, in the context here considered, calculation of the societal cost of transport to and from the intermodal terminals on existing transport infrastructure (roads, rail and canals) is required, focus will be on short run marginal external costs, including the marginal external cost of damage to the road caused by an additional vehicle. If long term policy measures would however include building new transport infrastructure to connect intermodal terminals, long term marginal external costs would have to be added as well to account for the external costs caused by these new roads, rails and/or canals. External costs on the intermodal terminals itself (e.g. the external cost caused during transhipment) are not yet included in the model.

In Europe, various transport policies aim to initiate a shift of freight from unimodal road transport to modes that are environmentally more efficient. Intermodal transport, incorporating more environmental modes such as barge, rail and short sea shipping, has lower external costs in most of the trajectories (see for an overview of studies Kreutzberger et al., 2006). In 2007, the European Commission (EC) announced a European freight transport action plan. One of the concepts introduced is that of "green transport corridors". Green transport corridors include shortsea shipping, rail, inland waterways and road transport combinations to enable environmentally friendly transport solutions for the European industry. The EC also proposes to revise the Directive on the charging of road transport for infrastructure use (Eurovignette). These measures are planned to come into effect before 2011.

Since the external costs of road transport depend highly on the location, time and vehicle type, there are significant country-related differences for most external cost categories. Therefore, use was made of the external cost figures for road transport from De Ceuster (2004), for four main reasons:

- The study calculates values on a Belgian level (more specifically the Flemish part of Belgium).
- The study takes into account the five most important short term marginal external cost categories: air pollution, climate change, accidents, noise and congestion.[8] In addition, the short term marginal external cost of damage to the road, caused by additional trucks on the road, is taken into account (MEC road in Fig. 3).
- The study differentiates between different vehicle types, giving figures for diesel trucks.
- The study takes into account the effects of taxation of road transport (including excises and VAT on fuel, traffic taxes, taxes on insurance premiums and on maintenance of vehicles, Eurovignette, vehicle purchase taxes and registration taxes) in order to determine which part of the external costs is already internalized.[9]

Especially this last point is very useful, since it allows taking only the part of non-internalized external costs into account. Fig. 3 shows values for the marginal external costs and taxes for a heavy duty diesel truck for Flanders over the period 1991–2002. In 2002 total marginal external costs amounted to 0.52 €/km. Note the high and increasing proportion of congestion costs over the years, accounting for 747% of total short term marginal external costs in 2002, whereas the other external cost categories remained stable or gradually decreased. As can also be seen from this figure (the shaded area), the existing taxation system on heavy diesel trucks compensated for 26% of short term marginal external costs in 2002, leaving 74% of external costs non-internalized. This almost equals the proportion of congestion costs, so it could be said that this taxation system internalizes all the external cost categories, except the largest category, namely congestion.[10] Since congestion is very time

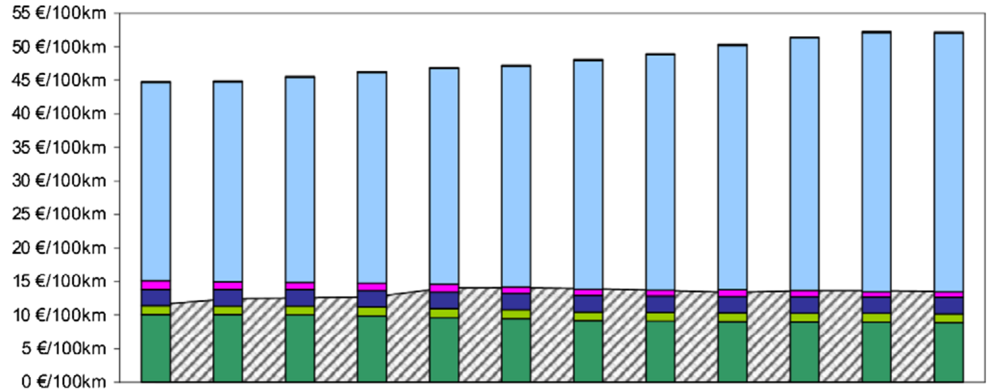
[6] Note that we calculate the impact of additional units of transported goods via road or intermodal transport, which means that we are interested in marginal rather than average external costs.

[7] For a recent summary of the different external cost categories, the most relevant studies in a European context and recently recommended key figures as proposed by the European Commission, see: *Handbook on estimation of external cost in the transport sector* (Maibach et al., 2008), produced within the IMPACT study (Internalization Measures and Policies for All external Cost of Transport).

[8] In De Ceuster (2004), the short-term component of up- and downstream processes which consists mainly of pre-combustion processes (=external costs due to energy production) is not taken into account as a short run marginal external transport cost.

[9] Abstraction is made of the fact that, ideally, transport users that cause higher external costs, should be taxed higher in order to give the correct price signal to transport users. Therefore, taxes should vary according to place (urban, non-urban), time (peak, off-peak) and vehicle characteristics (EURO-norm). This differentiation however is achieved only very partially in current road taxation schemes.

[10] In a recent publication of the Federal Planning Office, Hertveldt et al. (2009) calculated that the taxation level for trucks was 0.14 €/km for 2005 and would decrease to 0.12 €/km in 2030 with unchanged taxation policy and expressed in year 2000€. The marginal external congestion cost for trucks during peak traffic was calculated to be 0.80 €/km in 2005 and would rise to 2.21 €/km in 2030 with fixed road infrastructure capacity. During off-peak, values were 0.19 €/km and 0.34 €/km for 2005 and 2030, respectively. Since only air pollution, climate change and congestion were considered in Hertveldt et al. (2009) (no accidents and noise), figures from De Ceuster (2004) were used for truck transport in our research.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TAXES	11,536	12,451	12,572	12,684	14,006	14,083	13,926	13,657	13,375	13,622	13,644	13,521
MEC ROAD	0,141	0,141	0,141	0,141	0,141	0,141	0,141	0,141	0,141	0,141	0,141	0,141
MEC CONGESTION	29,566	29,839	30,590	31,371	32,160	32,895	34,079	35,109	36,448	37,613	38,626	38,548
MEC ACCIDENTS	1,280	1,109	1,053	1,094	1,180	0,951	0,971	0,892	0,977	0,919	0,777	0,842
MEC NOISE	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454
MEC CLIMATE	1,300	1,295	1,321	1,322	1,324	1,325	1,315	1,326	1,329	1,333	1,335	1,342
MEC AIR	10,068	10,058	10,015	9,880	9,613	9,449	9,126	9,041	9,006	8,953	8,902	8,856

Fig. 3. Marginal external costs versus taxes – heavy truck diesel, Flanders, 1991–2002. Source: translated from De Ceuster, 2004; MEC climate and MEC air are derived from Vito (Flemish Institute for Technological Research), 2003. Note: MEC = marginal external cost.

and location dependent, this implies that an optimal internalisation scheme for external congestion costs would require the introduction of some form of differentiated congestion charging depending on traffic intensity. In our analysis, the average marginal external congestion cost figures used in the study of De Ceuster (2004) will be applied in order to model the full internalisation since we assume that a differentiated full internalisation will be technologically feasible in the near future.

In a recent publication of the Belgian Federal Planning Office, Hertveldt et al. (2009) calculated the proportion of congestion costs in the total of congestion and direct environmental external costs for Belgium for 2005 and 2030. The results showed that in 2008 during peak traffic the proportion of congestion is well above 80% and still more than 50% during off-peak (above 95% in peak and about 80% off-peak in 2030), but since important external cost categories such as accidents and noise are not considered in Hertveldt et al., comparison with the results from De Ceuster (2004) is not straightforward. However, the study seems to confirm the trends visible in Fig. 3: an increase in marginal congestion costs and a decrease in the other marginal external cost categories (due to advances in the field of car technology, traffic safety, legislation, etc.). It is expected that this trend will continue in the future.

3. Analysing fuel price increases with the LAMBIT model

In this section the methodology of the LAMBIT model is explained, followed by the results of the fuel price scenarios. In Section 3 the internalisation of external costs is analysed with the LAMBIT model to compare this policy measure with the effect of fuel price scenarios on the modal share.

3.1. Methodology

LAMBIT is a geographic information system (GIS)-based location analysis model which makes it possible to do ex-ante and ex-post analysis of policy measures in favour of intermodal transport. The LAMBIT-model starts from a reference scenario which includes all the existing intermodal terminals and current market prices. The reference scenario serves as benchmark. Different policy measures are applicable:

- Location of new terminals.
- Price scenarios.
- Subsidies.
- Internalisation of external costs.

3.1.1. Construction of the model

LAMBIT is built on three main inputs: transportation networks, transport prices, container flows from the municipalities to and from the port of Antwerp.

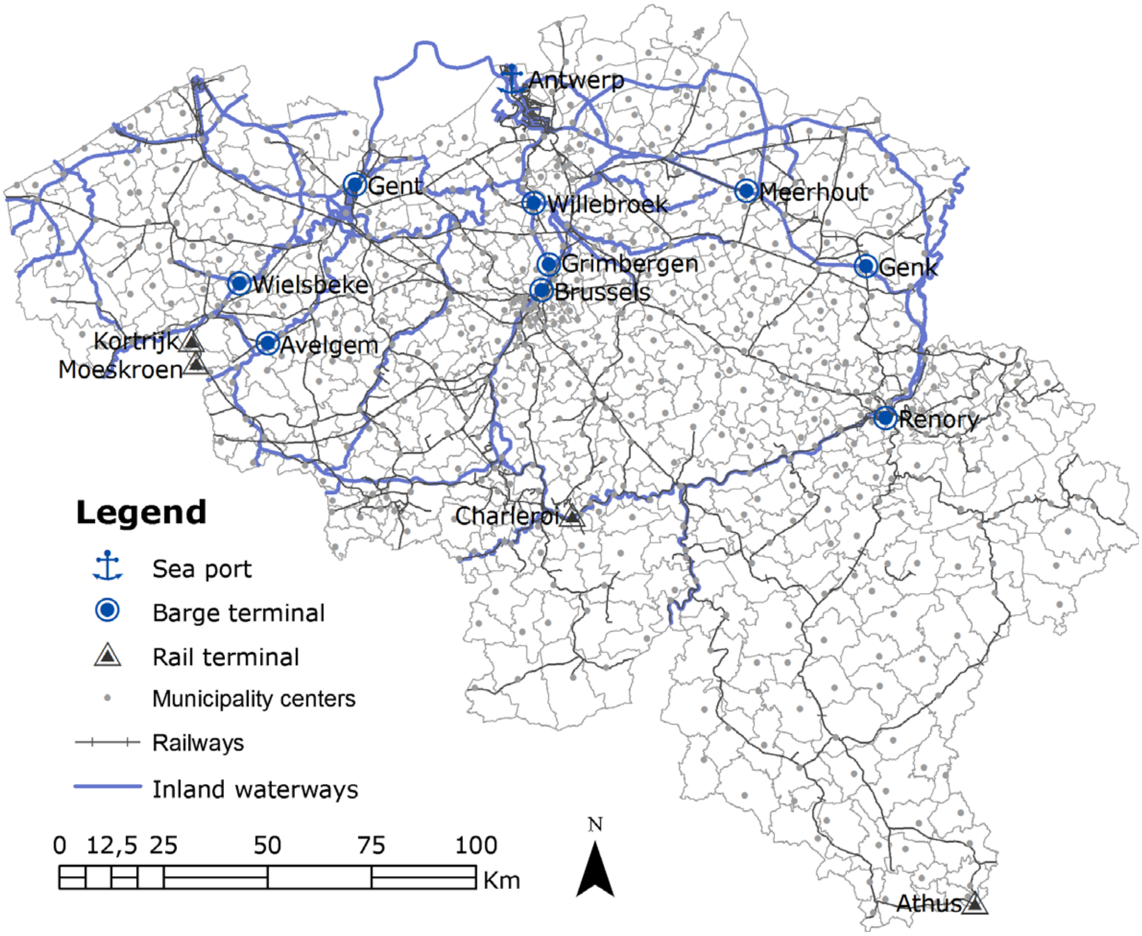


Fig. 4. Network layers and nodes. Source: VUB, MOSI-T.

3.1.1.1. Transportation networks. LAMBIT is a GIS-based model, consisting of the different network layers (for each transport mode) and the location of the intermodal terminals and the port of Antwerp (as nodes in the network) (Macharis, 2000, 2004). A GIS network was set up by including four different layers: the road network, the rail network, the inland waterways network and the final haulage network. The geographic locations of the intermodal terminals and the municipality centres are defined and connected to the different network layers.

Fig. 4 depicts the different network layers and nodes inclusively nine inland terminals and four Narcon[11] rail terminals. The networks for Belgium were built by merging the following digital databases:

- Road layers and municipalities are obtained from the MultiNet database of Tele Atlas.
- Rail and inland waterways layers are extracted from the ESRI (Environmental Systems Research Institute) dataset for Europe.

3.1.1.2. Transport prices. The LAMBIT methodology is based on two concepts: the intermodal cost structure and the break-even distance. Considering the total transport prices and the distance travelled, unimodal road transport is cheaper in the short distances but once the break-even distance is achieved, intermodal transport offers a competitive alternative.

The transport prices are calculated based on the real market price structures for each transport mode and they are associated with the network layers. The variable costs are uploaded to the network layers and the fixed costs are attached to the nodes, which also indicate the origin and destination for each path.

The total price of intermodal transport is composed of the transhipment cost in the port of Antwerp to a barge or a wagon, the cost of the intermodal main haul (barge or rail), the transhipment cost in the inland terminal to a truck and the cost of final haulage by truck. The following formula explains the calculation of intermodal transport:

[11] National Rail Container Network.

$$\mathrm{IT} = \mathrm{PH} + \mathrm{TH} + \mathrm{MH}$$

In which:

– IT: price of intermodal transport.
– PH: price of pre/post haulage by road transport.
– TH: price of terminal handling in intermodal terminals.
– MH: price of main haulage by barge or rail transport.

The total intermodal transport cost is obtained by adding all of these fixed and variable costs based on the existing market prices.

3.1.1.3. Containers from the Belgian municipalities. The final input for the LAMBIT analysis is the container flows from the port of Antwerp. In this paper, the statistics of road transport from the Directorate-general Statistics and Economic Information of Belgium was used.

3.1.2. Functioning of the model

Using a shortest path algorithm in ArcInfo, various comparisons are conducted in order to find the shortest path and the attached transport price from the port of Antwerp to each Belgian municipality via intermodal terminals and via road only. For each destination, the total transport price for unimodal road, inland waterways/road and rail/road transport are compared and the cheapest option is selected. The output consists of the market areas of each inland terminal are highlighted in the map of the model. These visualisations help us to see how large the market area of each intermodal terminal is. As a further step, the container flows data can be used to show the amount of containers that are currently transported by road to the municipalities within the market area, which gives an indication of the existing potential volume that can still be shifted. This is particularly useful when a location of a new terminal needs to be analysed.

3.2. Fuel price scenarios

Three fuel price scenarios are analysed with the LAMBIT model based on forecasts of the EIA (cfr. Section 2.1.1). The fuel price increases have an impact on the variable costs of transport modes.

The reference scenario (map I) in Fig. 5 presents the existing intermodal inland terminals with their market areas. The green areas represent the market area of intermodal waterway terminals; the red/orange areas show the market area of the intermodal rail terminals. In this reference scenario, nine barge/road (inland waterways) terminals and four rail/road terminals are included. Current market prices are used to show the market area of the current terminals. The municipalities are highlighted, when intermodal transport has a more attractive transport price compared to unimodal road transport based on the current market prices.

The low price scenario (map II) in Fig. 5 demonstrates the impact in the terminal landscape of a retail fuel price increase of 10% due to an increase of the Brent price of 30%. Compared to the reference scenario with the current market prices, the fuel price is gradually increased. A 10% increase in fuel prices shows a minor decrease in the market areas of barge terminals. The terminals in Genk and Renory lose respectively 3 and 5 municipalities to unimodal road transport. In contrast, the terminals in Brussels and Meerhout increase their market areas by 1 municipality each. Considering the rail terminals, minor growth in the market areas of the terminals in Athus and Charleroi is observed. Intermodal rail transport cannot compete with unimodal road transport on a short distance.

When the fuel price is increased by 50% (map III), unimodal road transport begins to lose market area. Almost all of the barge terminals increase their market areas. Only the terminal in Ghent is still not able to compete with the prices of unimodal transport. The intermodal terminals in Wielsbeke and Meerhout increase their market areas by more than five municipalities. Furthermore, the 50% fuel price increase leads to a significant growth in the market area of the rail terminals in Charleroi and Athus. Theoretically a modal shift will occur when the retail fuel price increases with 50%.

Finally, the high price scenario (map IV) represents a 90% increase of fuel price which also leads to larger market areas for the barge terminals. Unimodal road transport loses 35 municipalities to the barge terminals. The expansion of the market area for inland waterways transport is most outspoken for the terminals in Wielsbeke and Brussels, where the terminals increase their market areas by 10 and 7 municipalities respectively. The market areas of the rail terminals also alter with the 90% increase of fuel prices. In addition to the growth in the market areas of Charleroi and Athus, the rail terminals in Kortijk and Moeskroen are also able to attract some market area.

3.3. Internalisation of external costs

The effect of a fuel price increase is compared with the policy measure of internalising the external costs. In order to analyse the effect of an internalisation of the external costs on the market area of intermodal transport, first the cost functions of the LAMBIT model were adapted. As described in Section 2, taxes on road transport do not cover all of the external costs of this mode. However, not taking them into account would bias the analysis. Therefore, current road taxes were subtracted

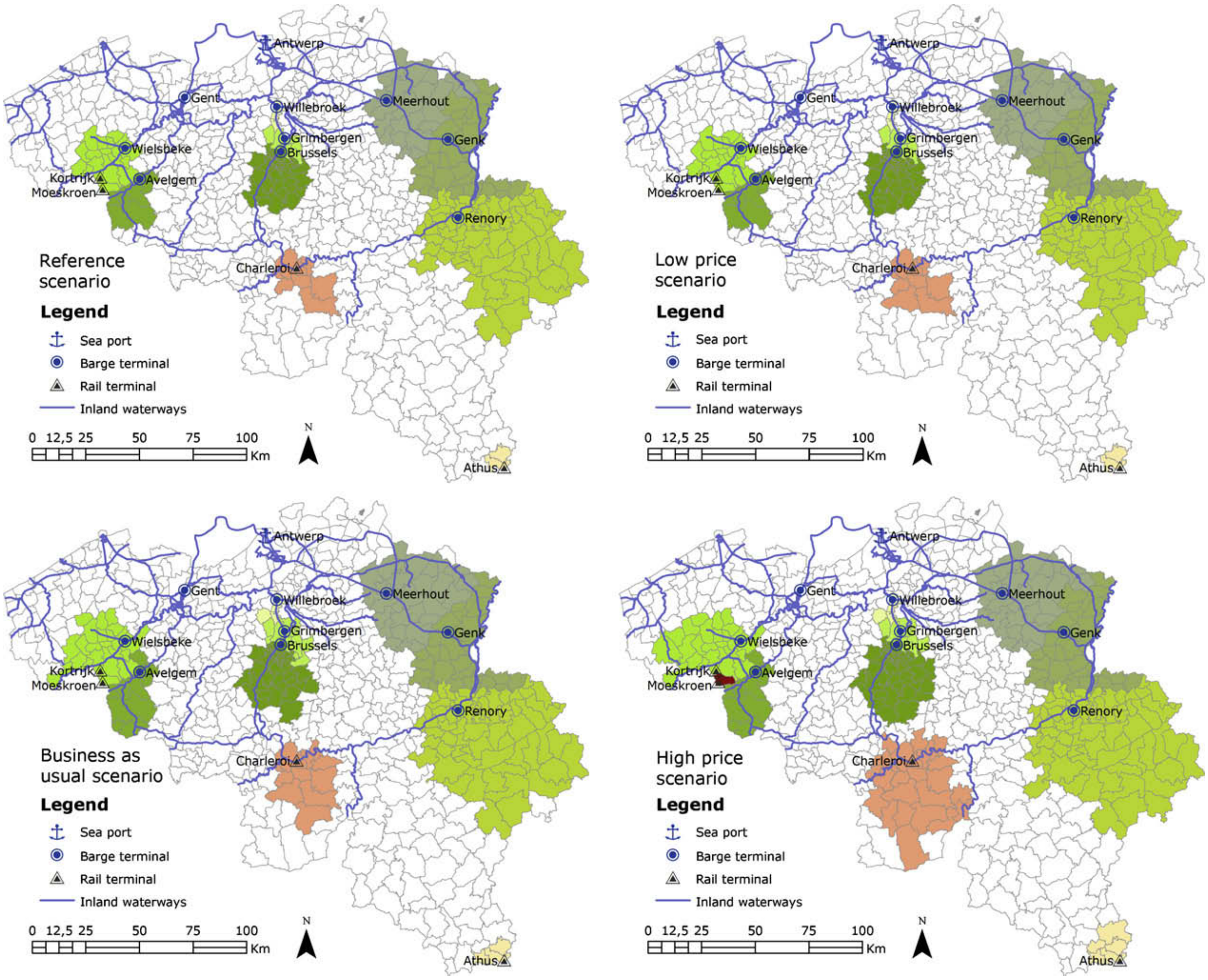


Fig. 5. Fuel price scenarios. Source: VUB, MOSI-T.

from the total external costs for road. It should be mentioned that no taxes are applied to inland waterways and rail transport. Next step was to calculate external costs per TEU. Table 2 shows the average values for marginal external costs for each transport mode that is used in the LAMBIT analysis. These costs include all costs related to the usage of transport infrastructure such as accident costs, noise, air pollution, climate change and congestion (Section 2.3).

Fig. 6 shows the internalisation of external costs for all modes of transport. The costs of transport modes are internalized based on current market prices and no subsidies for rail and inland waterways transport are taken into account. The analysis indicates an increase in the market areas of intermodal terminals but the impact differs for rail and barge terminals individually. This is explained by the difference in the external costs for each transport mode.

The major change occurs in barge terminals. While the terminal in Genk, Willebroek and Grimbergen face a moderate growth in their market areas, the terminals in Brussels, Renory and Wielsbeke experience a considerable growth. Another interesting finding of this analysis is that the terminal in Gent has the potential of acquiring up to 10 municipalities by offering cheaper transport prices compared to the unimodal road transport. Considering the rail terminals, the terminals in Athus and Charleroi can increase their market areas. Both terminals now reach municipalities which were formerly in the market area of the unimodal road transport. Nevertheless, an internalisation of the external costs do not lead to any market area for the rail terminals in Wielsbeke and Avelgem.

Table 2
The marginal external costs in €/TEU. Source: VUB, MOSI-T data based on De Ceuster (2004) and De Vlieger et al. (2004).

Year	Road	Rail	Barge
2002	0.39	0.07	0.06

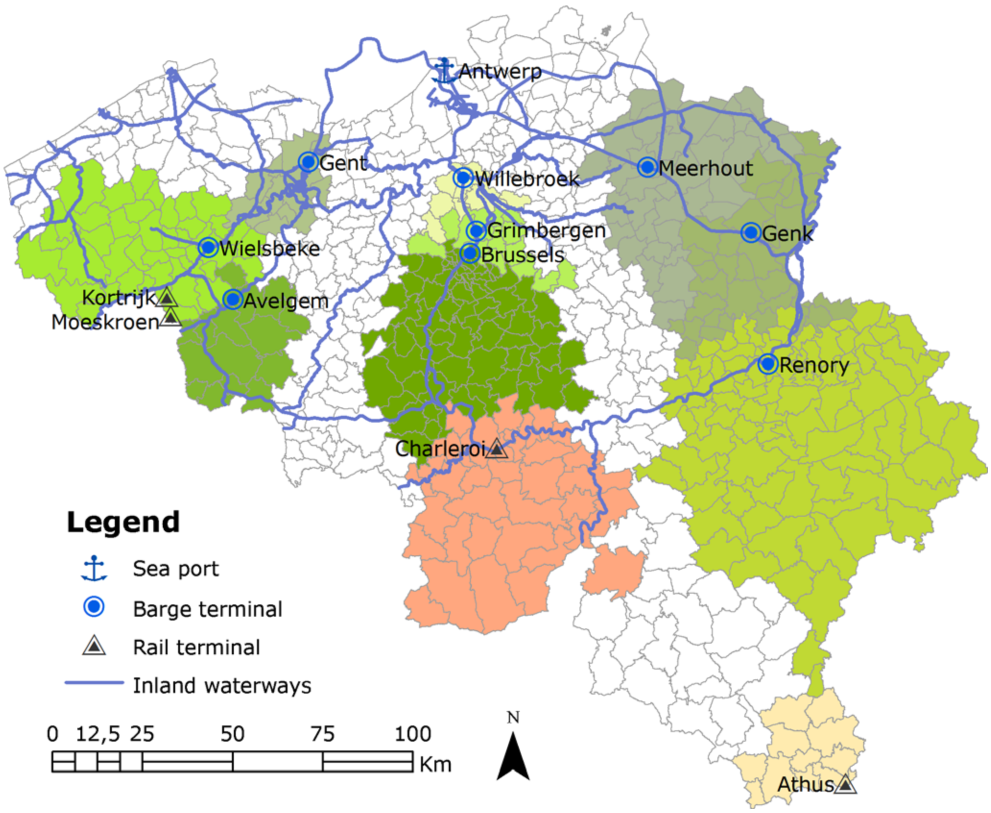


Fig. 6. Internalisation of external costs. Source: VUB, MOSI-T.

Overall, it can be concluded that the impact of the policy instrument 'internalisation of external costs' on the market area of intermodal transport is larger than the effect of an increase in fuel price. Even if the fuel price is almost doubled, it still cannot compete with internalisation of external costs. It is therefore the government who will have to apply (additional) policy instruments in order to fully stimulate the use of intermodal transport to make the transport system more sustainable. A fuel price increase alone will be beneficial from a sustainability viewpoint, but to a more limited effect than a full internalisation of external costs. It should however be noted that the political acceptability of a full internalisation of external costs is still the subject of strong debate.

3.4. Break-even analysis

The break-even analysis, as explained in Section 2, is also an output from the LAMBIT model. The cost line of both road transport and intermodal barge transport will become steeper as the fuel price increases. In this analysis the pre/post haulage costs of intermodal barge transport is included. The graphs in Figs. 7 and 8 show that above a certain distance, inter-

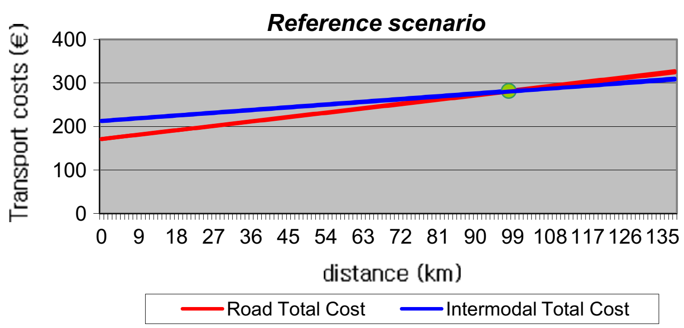


Fig. 7. Break-even analysis: reference scenario. Source: VUB, MOSI-T.

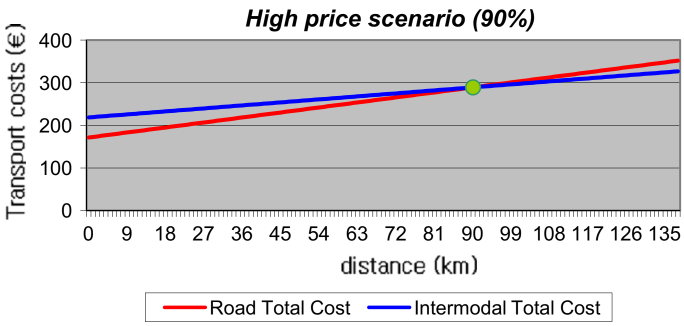


Fig. 8. Break-even analysis: high price scenario. Source: VUB, MOSI-T.

modal barge transport costs are lower than those of road transport. The point where the lines intersect is the break-even point: at this distance the costs of road and intermodal barge are the same.

The break-even distance for the reference scenario is 99 km as visualized in Fig. 7. A decrease of the variable, distance related, costs (fuel price increase) will make the line steeper. This will shift the break-even point to the left as illustrated in Fig. 8. The break-even distance will decrease with 11 km when the fuel price increases with 90% to a new break-even point at 88 km. We can conclude that the break-even distance decreases with a rather small degree because of the included pre/post haulage costs which rise along due to the fuel price increases.

4. Conclusions and future steps

This paper presented a geographic information system (GIS)-based location analysis model for evaluating fuel price increases on the market area of intermodal transport. The LAMBIT-model makes it possible to make ex-ante and ex-post analysis of policy measures to stimulate the intermodal transport market. Based on the current market prices for each transport mode, the model compares intermodal transport with unimodal road transport. Based on forecasts of the Energy Information Administration future oil price scenarios were set up and converted to diesel prices taking into account that the price of crude oil affects the diesel price in Belgium for 40%.

The analyses on the different fuel price scenarios described in this paper show that fuel price increases result in an increase in the market areas of intermodal terminals. Theoretically the scenarios reveal that both intermodal barge and rail terminals increase their market areas if the fuel price increases, but the result differs depending on the size of the increase. If the fuel price increases with a small degree, intermodal transport is less interesting because the price of pre/post haulage increases also while the additional price effect on the long haul is relatively limited. An interesting situation for intermodal transport is created when the fuel price increases with a significant level. Then the break-even distance becomes significantly smaller due to the stronger price advantage for intermodal transport on the long haul.

The government can also stimulate the use of intermodal transport via several policy measures. The internalisation of external costs is briefly described in this paper and analysed with the LAMBIT-model. It is remarkable that even when the fuel price is doubled, it cannot compete with the effect of a full internalisation of external costs on the market area of intermodal transport. It is thus the responsibility of the policy makers to make intermodal transport more attractive as it has environmental as well as cost benefits. Although the European Commission is a strong advocate for internalisation, the political viability of a full internalisation of external costs is however still source of much debate.

Further refinements in analysing intermodal versus unimodal transport can be achieved in the future by including other decision variables such as service, transport time, generalised costs in the model and to expand the LAMBIT framework towards markets in Benelux or Europe. It would also be interesting to validate the model by matching it with reality by comparing what actually happens with the market share of intermodal terminals once fuel prices have risen with the amount predicted in the future scenarios. Modal choice is not only depended on price as single factor (although it is usually the most important one), but depends also on transport time, reliability, flexibility, etc. This is not yet taken into account in our model.

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