THE POSSIBILITIES OF INTERMODAL TRANSPORT IN PRACTICE

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ABSTRACT

This paper analyses the question whether it is strategically interesting for a company to choose for intermodal transport. A feasibility study has been carried out for the company 'Colruyt' to give an answer to this question. The transportation cost of different flows of goods, from the Port of Antwerp to the distribution centers of Colruyt, has been calculated, by road and by intermodal transport. This feasibility study has been complemented with an analysis done with the LAMBIT-model (Location Analysis Model for Belgian Intermodal Terminals) to determine the location of the optimal intermodal terminal for the different distribution centra (Halle and Ghislenghien). Finally a calculation of the external costs has been carried out to compare the external costs of transport by road and those of intermodal transport. This analysis shows the external costs Colruyt could avoid when choosing for intermodal transport instead of road only.

Keywords: intermodal transport, LAMBIT, external costs.

1. INTRODUCTION

"Intermodal transport is the transport of goods, in one and the same loading unit, with minimum two different transport modes, without manipulation of the goods during the change of transport mode" (C. Macharis and Y.M. Bontekoning, 2004). **Unimodal transport** is just the opposite, here one transport mode is used, mostly road transport. The growth in maritime container traffic has contributed to a more intensive use of intermodal transport and also to the necessary volume to start up terminals in the hinterland. This paper shows that it can be

strategically interesting for a company with respect to its competitors and financially interesting to use intermodal transport for certain flows, in this case for the company Colruyt (one of the largest supermarket chains in Belgium). In section 2 intermodal transport is defined. In section 3 a feasibility study is carried out for the company Colruyt. The transport cost from the Port of Antwerp to the distribution centers of Colruyt is calculated, both for unimodal transport and intermodal transport. Section 4 describes which intermodal terminals are the most interesting for Colruyt using the LAMBIT (Location Analysis Model for Belgian Intermodal Terminals) analysis developed by Cathy Macharis (Macharis, 2000) Using the LAMBIT method one can determine the optimal location of the terminals for the different distribution centers of Colruyt. The terminal with the lowest transport cost is indicated as the terminal that is optimal for Colruyt. With this analysis it can be tested if these accord with the costs that were calculated in the feasibility study. In the last section we calculate the external costs of unimodal and intermodal transport, again for the company Colruyt. On this basis the saving in external costs by switching to intermodal transport can be calculated.

2. INTERMODAL TRANSPORT AND THE INTERMODAL CHAIN

The different transport modes of intermodal transport are rail, barge, short sea shipping and road traffic. Freight traffic has known a sharp increase over the past years, especially for road transport. In view of the exploding environmental issues the avoidance of road transport is encouraged as much as possible, because road transport has the most adversely effects on the environment. Intermodal transport limits the use of road transport to the pre and post haulage from and to the intermodal terminal. The aim is to use each transport mode in the best possible way and to align the different modes optimally. Intermodal transport consists of three main operations: pre and post haulage, transshipment and the main transport. Pre and post haulage go in two directions, from the origin to the terminal and reversed. This is mainly done by road transport. In the terminal the transshipment is executed, the intermodal loading unit is transferred from the truck to a train, barge or short sea vessel or the other way around. Then the main transport is done by train, barge or short sea vessel. Below an illustration (figure 1) of the intermodal chain is shown. The containers are brought to the terminals by trucks, where they are transported to the subsequent terminal by railway or inland navigation. In this last terminal the containers are transferred to trucks and finally transported to the destination.

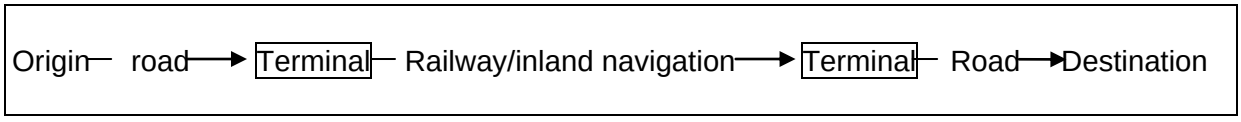

Figure 1: The intermodal transportchain - Own setup

3. FEASIBILITY STUDY INTERMODAL TRANSPORT

Colruyt is one of the largest supermarket chains in Belgium. Colruyt exploits over 350 stores in Belgium and France. Colruyt group is the holding of the following store formats: Colruyt, Okay, Dreamland, Collishop and Dreambaby. Besides this the concern disposes of a number of wholesalers, who supply to the Spar stores, and petrol stations named DATS 24. The turnover in the year 2008-2009 was 3,56 billion euro. They have establishments all over Belgium. Their mission is to have to lowest prices on the market for every product compared to their competitors. Besides this they also pursue a green image. This study is a part of this mission to work on more environmentally friendly transport.

The first part of the study consisted of a feasibility study to shift the transport of containers by trucks to transport by rail or barge. Before the study was carried out the containers arrived at the Port of Antwerp where they were fetched by Colruyt and transported by trucks to the different distribution centers. Colruyt had distribution centers in Halle, Lot, Courcelles, Pommeroeul, Baudour and Ghislenghien. Colruyt wanted to look into the option to transfer the containers from the Port of Antwerp to an inland terminal by rail or barge and from there to the different distribution centres by truck. The possible intermodal terminals were the Port of Brussels (CFNR Brussel) for the DC's in Halle and Lot and the rail terminal of Charleroi for the DC's in Ghislenghien, Courcelles, Pommeroeul and Baudour. Because Ghislenghien lies in between Brussels and Charleroi we calculated the transportcost both for the inland terminal in Brussels and the rail terminal in Charleroi. The tariffs used to calculate the transport cost are tarrifs that were obtained bij Colruyt. There always two tariffs per trip, one where the container returns empty to the Port of Antwerp and one where the container is used by another company and does not has to return empty. It speaks for itself that the latter is more interesting than the former.

3.1 Subsidies

When it comes to subsidies the subsidy scheme in Belgium is not uniform for the whole country. First of all there is a different arrangement for rail and barge. The subsidy scheme for the inland waterways are established at a regional level, the subsidy scheme for railway transport on the other hand is established at a federal level. In figure 2 below the different schemes are shown.

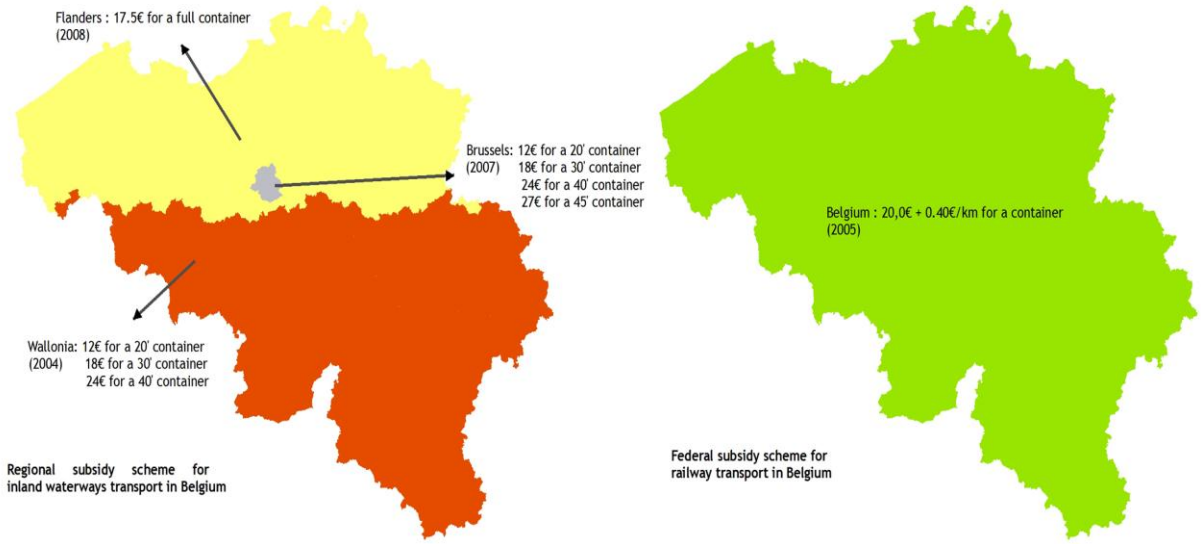

Figure 2: Subsidy schemes in Belgium for intermodal transport - MOSI-T

This gives the following subsidies for the Port of Brussel: 12 euro per transferred container of 20 feet and 24 euro for a container of 40 feet. The subsidies for the transport by rail amounts to 20 euro per container plus a variable part of 40 cent per kilometer. The distance between the Port of Antwerp and Charleroi amounts to 96,43 kilometer. This gives us a total subsidy of 58,57 euro per container.

Table 1: Subsidies Colruyt - Own setup

Barge		20 FT	40 FT
Antwerp → Brussels		**12 €**	**24 €**
Rail			
Antwerp → Charleroi	96,43 km	**58,572 €**	**58,572 €**
		(=0,4*96,43 + 20 €)	

3.2 Results

After calculating the transport cost of the different trips we can conclude the following:

For food containers:

- Road transport has almost every time, except for the DC in Courcelles, an advantage over intermodal transport when the container **has to return empty**.
- When the container **does not have to return empty**, the inland terminal of Brussels is more advantageous than road transport for the DC's in Halle and Lot. Both for the containers of 20 feet and 40 feet. For the DC of Ghislenghien transport by barge is more advantageous for containers of 20 feet and transport by rail for containers of 40 feet. For the DC's in Baudour, Courcelles and Pommeroeul transport by rail is the most interesting mode for both type of containers.

For non-food containers:

- Again unimodal road transport is the most interesting option when the container had to return empty for every DC except for the one in Courcelles.
- When the container does not have to return empty, transport by barge is the most profitable option. The DC of Pommeroeul is served the most profitable by rail for containers of 20 feet and by barge for containers of 40 feet. The DC's in Courcelles,and Baudour have the lowest cost when the containers are transported by rail.

When comparing the total transport cost of intermodal transport and unimodaal transport, we see that Colruyt saves 12,07% of their total transport cost by switching from trucks to intermodal transport modes (barge or rail).

Conclusion: When there is no empty return of the container inter modal transport is a profitable alternative for the transport of the container flows of Colruyt. Furthermore it turns out that by switching from unimodal to intermodal transport the transport costs even decreases. It is possible for Colruyt to ensure that the containers do not return empty, so intermodal transport is a feasible option for them.

The feasibility study was also carried out in the case there wouldn't be assigned subsidies to Colruyt. The conclusions are in the line of the one with subsidies. When the container has to return empty, road transport is the most profitable alternative. When the container does not return empty intermodal transport is often a more advantageous option. For food containers the transport by barge is more interesting for the DC's of Halle and Lot than unimodal transport. For the DC of Ghislenghien barge is more profitable for containers of 20 feet and rail for containers of 40 feet. The DC's in Baudour and Courcelles are served most profitably by rail for both types of containers. The same holds for non food containers. Inland waterways is, when the container does not return empty, the most profitable option for the DC's in Halle and Lot. Only the transport of containers of 40 feet to the DC of Lot is more profitable by road transport. The transport to the DC's of Courcelles and Ghislenghien is again the most advantageous by rail and the DC of Pommeroeul is attainted the cheapest by barge for containers of 20 feet and by rail for containers of 40 feet.

It appears that even when Colruyt does not obtain any subsidies, most of its container flows are transported the most profitable by intermodal transport.

When the total cost is studied in this case, it appears that it is still interesting to use intermodal transport, even if in this scenario there are no subsidies assigned. A transition from unimodal to intermodal transport yields a saving of 3,35%.

4. ANALYIS USING THE LAMBIT-MODEL

The second part of the study was the Location Analysis for Belgian Intermodal Terminals (LAMBIT) model (Macharis et al., 2008). This method makes it possible to determine whether

the distribution center of Ghislenghien and the distribution centers in Halle fall within the market area of the rail terminal of Charlerloi, respectively the market area of the barge terminal of Brussels. The market area of a terminal is the area which contains the municipalities that are served most profitable from this terminal. The LAMBIT-model is based on the Belgian intermodal network. First 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.Then the transport cost for each transport mode is calculated. Thereafter de cheapest mode is selected. The model displays and visualizes the market area of each terminal and represents the volume of containers that currently is transported by trucks. (Macharis et al. 2008) This gives an idea of the volume that can be shifted from the road to the inland waterways or rail. This part of the study was executed using average tariffs for reach terminal that are included in the database of the model and not the tariffs that Colruyt obtained. These tariffs are however are not very different, so this study is still relevant for Colruyt.

In figure 2 below the intermodal transport chain is shown, specific for the LAMBIT-model. The origin is the Port of Antwerp, where the containers arrive. From there the containers are brought to the inland terminal by rail or barge. In the terminal the containers are transferred and brought by truck to the different destinations (municipalities).

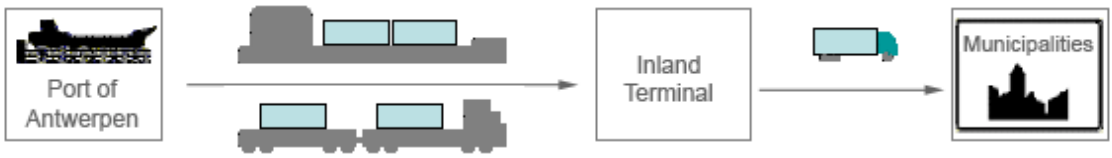

Figure 3: The intermodal transport chain - Macharis. C., Pekin E. (2007)

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

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.

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 and 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.

Figure depicts the different network layers and nodes inclusively three intermodal. 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

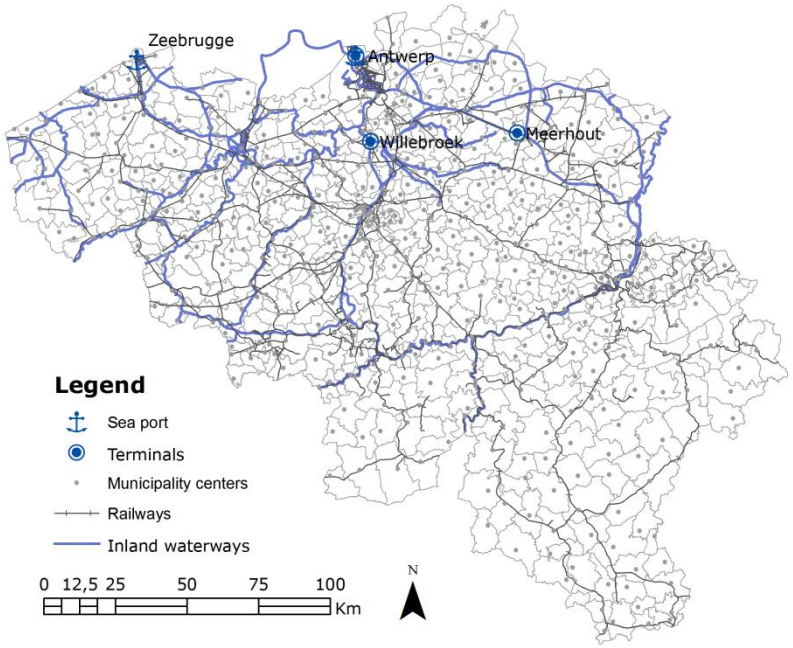

Figure 4: Network layers and node - Own setup

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:

IT = PH + TH + 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. Containers from the Belgian municipalities

The final input for the LAMBIT analysis is the container flows from the sea ports. In this paper, the statistics of road transport from the Directorate-general Statistics and Economic Information of Belgium was used.

4.1 Scenario without inland waterway subsidies

In this scenario we start from a situation without inland waterway subsidies. The railway subsidies are included in the scenario. Figure 5 below shows that in this case the DC's in Halle are located withing the market area of the terminal of Brussels. In this scenario the most advantageous transport mode is barge for the transport flows from Antwerp to Halle, after that road transport is the most interesting alternative. The DC of Ghilenghien is however not located in the market area of Charleroi, but it is also not located in the market area of another terminal (Brussels, Avelgem, Moeskroen). Road transport is the cheapest transport mode in this scenario, followed by rail via the terminal of Moeskroen.

In the figure below the different terminals and their market area is shown by the colored areas round the terminals. The two DC's are represented by the stars.

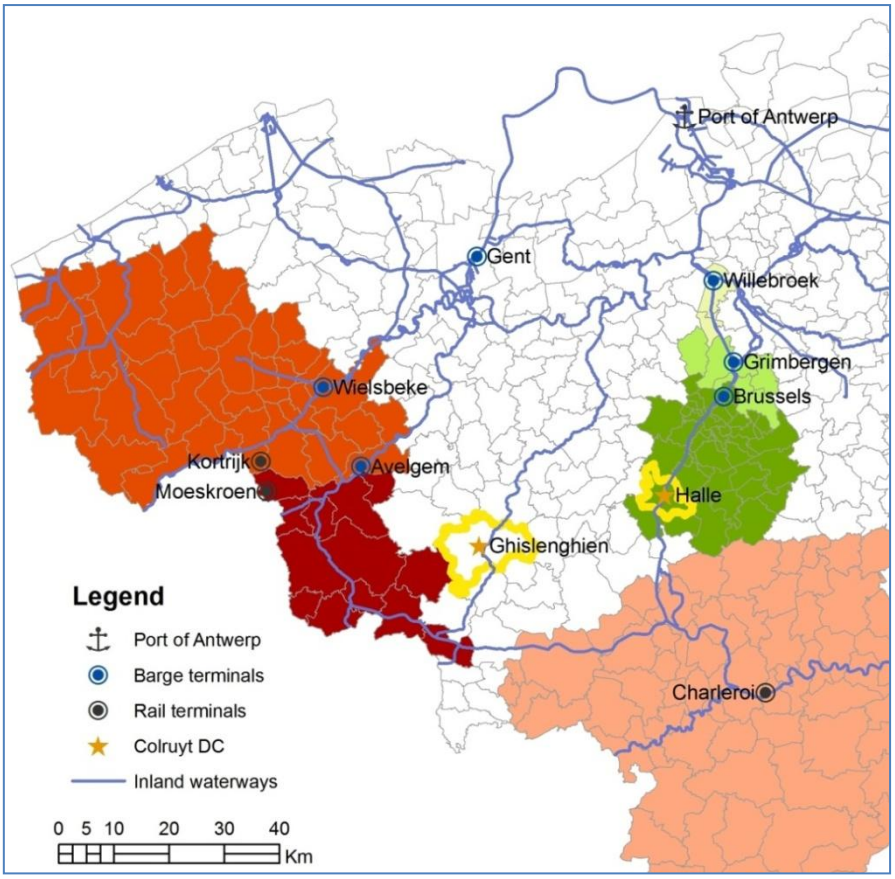

Figure 5: Analysis LAMBIT without inland waterway subsidies – MOSI-T

4.2 Scenario with inland waterway subsidies

When we add the inland waterways subsidies to the model the situation is different. Figure 6 below shows the changes in the market areas of the different terminals. The DC's of Halle are still in the market area of Brussels, which is logic since this was already the case in the scenario without inland waterway subsidies. The DC of Ghilenghien is still not in the market area of one of the terminals, but is now closer to the market area of the barge terminal of Avelgem. After unimodal road transport, barge is now the most interesting alternative. By adding the subsidies the market area of the barge terminals has expanded enormously, where the area was for some of the barge terminals non existing in the previous scenario.

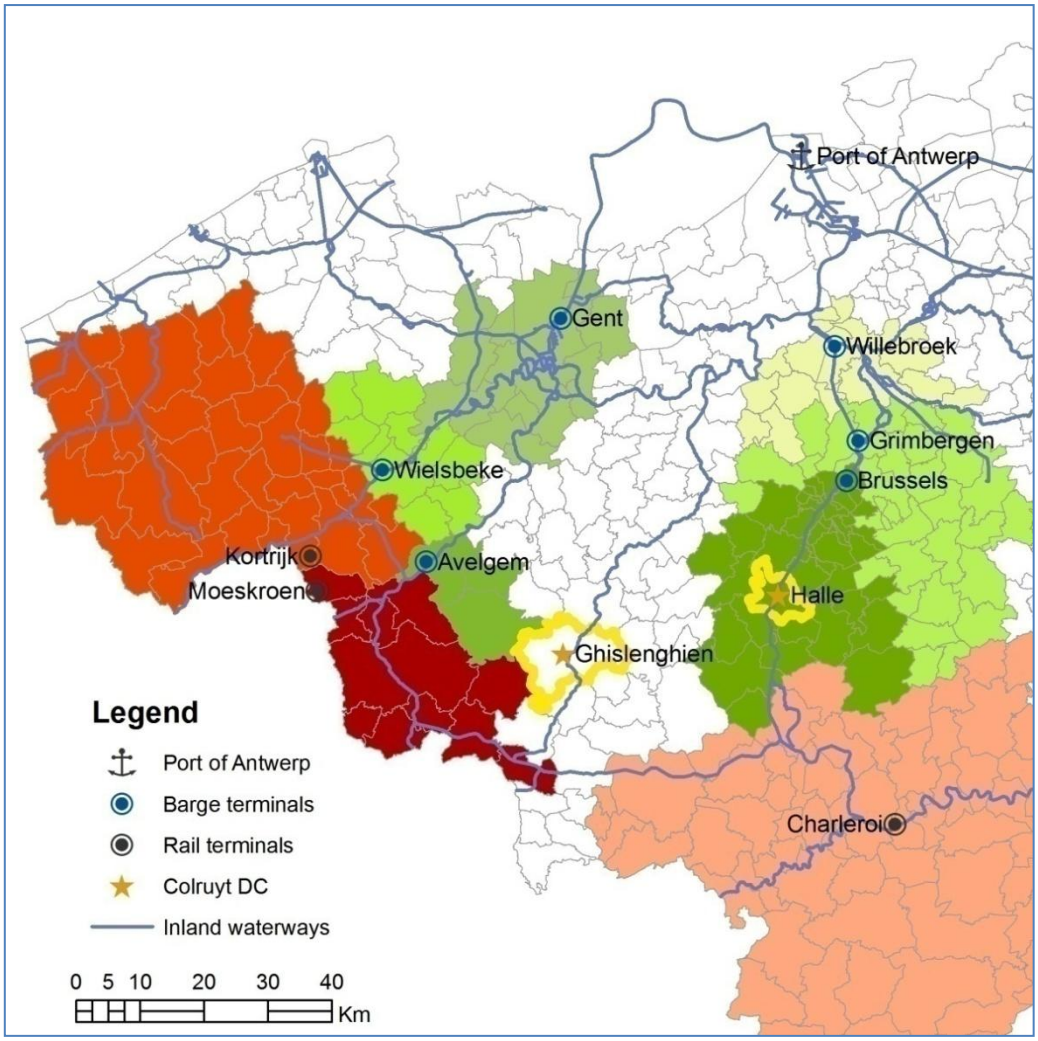

Figure 6: Analysis LAMBIT with inland waterway subsidies – MOSI-T

5. EXTERNAL COSTS

In this section the external costs are calculated and analyzed. These calculations give an indication of the difference between the external costs caused by unimodal transport and those caused by intermodal transport. The external costs can be calculated using the manual on external costs of CE Delft (CE Delft 2007). First some assumptions have to be made concerning the euroclass of the trucks, the weight of the freight, the type of barge, etc. This gives us the external cost for each transport mode. Then the total external cost can be calculated for unimodal transport and intermodal transport taking into account the proportions of each transport mode.

'**External effects** are the real effects that are not taken into account by the road user when he or she takes a decision about transport and logistics' (Dijst en Van Wee, 2003). As a consequence road users receive a wrong incentive for the supply and demand of transport, which lead to welfare losses. There are three types of external effects. First of all we have the effects that arise as a consequence of the transport activities and the use of transport vehicles. For example congestion, road accidents, etc. Second we have external costs that

arise because of the possession and the presence of transport means. And the last type is the transport infrastructure itself, because it causes damage to the landscape when it is build.

The external cost is the part of the social cost that is not reflected in the price, but is born by the community. The difference between the social and private cost is the external cost. Social costs are all the costs that are related to the use of the transport infrastructure: congestion, wear and tear, capital, environment and accident costs. Private costs are the costs borne by the users of the transport.

There are different categories of external costs:

- Congestion costs:
  These costs are caused by the road transport and they represent the greatest share of the external costs. These costs are closely linked to reliability and are dependent of place, time, roadworks, etc. These costs make the difference between unimodal road transport and intermodal transport very clear, since the latter only makes use of trucks for the pre and post haulage. If the pre and post haulage take place in periods without congestion intermodal transport contributes to the avoidance of external costs.
- Scarcity costs:
  These costs mainly occur with scheduled transport, for example opportunity costs, delay costs and the lost time for the users of transport. Just like congestion costs, scarcity costs are dependent on time and place.
- Accident costs:
  These costs consist of medical costs, the loss of a human life and production losses. Intermodal transport gains an advantage in respect to road transport for this category, since the risk on accidents is lower for railway and inland navigation.
- Air pollution:
  Air pollution entails medical costs, but also the loss of crops, damage to buildings and it is detrimental for the health. The degree of air pollution is strongly dependent of the type of vehicle and the condition of the vehicle, the duration of the transport, the speed and the type of infrastructure. Also for this category intermodal transport scores better than unimodal road transport, congestion on the roads increases this category of external costs.
- Noise:
  Noise results in health problems, annoyance and indirect it can cause a loss of rent. Concerning noise inland navigation has an advantage over railway and road transport.
- Climate change:
  Transport has an influence on the world, such as an increase in temperature and climate changes. This results in high costs, on the one hand to prevent these changes, on the other hand to reduce the effect of these changes. Road transport underachieves compared to the intermodal alternatives.
- Costs for nature and landscape:
  Transport infrastructure causes damage of nature and the landscape.
- Additional environmental costs:

Some types of transport and their emissions can cause additional costs, like pollution of water and soil.

- Additional costs in urban areas:
  In urban areas additional costs arise through the shortage of non-motorized transport and removal costs for pedestrians.
- Up- and downstream processes:
  These costs arise indirectly through the use of transport and transportinfrastructure.

The conclusion is easily drawn: road transport has the greatest share in the external costs. In most cases intermodal transport is better for the environment than unimodal road transport and it can contribute to the reduction of congestion on the roads. Trucks have the greatest share in external costs, followed by barge and last freight trains.

How can we take external costs into account? One solution is the internalization of external costs. This can be done using marketbased measures or command and control measures. With market based measures the person that causes the externality has to pay for it, for example congestion pricing or a fuel tax. Command and control measures on the other hand try to avoid the externality itself, for example emission restrictions, speed limits, etc.

Table 2 below gives an overview of the external costs per category and the total sum of the external costs per modus in euro for 2008 for Colruyt. This table is set up using own calculations using the numbers of Colruyt. Two different scenarios were used, one with an electric train and one with a diesel train. The last row represents the ratio unimodal road transport / intermodal transport.

After analyzing the external costs the following conclusions can be made. Intermodal transport is almost always more advantageous than unimodal road transport. This is the case for the category air pollution, climate change, congestion, accidents and up- and downstream processes, in the scenario with an electric train. When a diesel train is used this conclusion no longer holds for the category air pollution. Trains on diesel are more detrimental for the environment compared to road transport. Only for the category noise unimodal transport scores better than intermodal transport. Analyzing the total external costs we see that unimodal transport has external costs that are 2.8 times as high as those of intermodal transport. Especially for the category accidents, congestion and up- and downstream processes the difference is striking when looking at the ratio unimodal road transport/intermodal transport. This ratio also shows that in the case of diesel train the external costs of the category air pollution are much higher than those of unimodal road transport. Notable is the category noise, here the external costs of unimodal transport only amount to 22% of those of intermodal transport.

Table 2: Overview external costs per category for Colruyt in euro for 2008 – Own setup

Scenario electric train

	Externel cost category							
		Air pollution	Climate	Noise	Accidents	Congestion	Up- and down	**TOTAL**
UNIMODAL ROAD		7996,58	3639,36	8655,65	15985,95	242358,08	374625,98	**653261,60**
INTERMODAL	road	2299,24	1047,02	2518,84	4651,99	70527,42	109258,97	190303,48
	rail	108,66	243,49	36119,45	63,45	0,00	0,00	36535,05
	barge	3338,72	302,86	0,00	0,00	0,00	288,44	3930,02
	TOTAL	5746,62	1593,37	38638,29	4715,44	70527,42	109547,41	**230768,55**
UNIMODAL/INTERMODAL		**1,39**	**2,28**	**0,22**	**3,39**	**3,44**	**3,42**	**2,83**

Scenario dieseltrain

	External cost category							
		Air pollution	Climate	Noise	Accidents	Congestion	Up- and down	**TOTAL**
UNIMODAL ROAD		7996,58	3639,36	8655,65	15985,95	242358,0775	374625,98	**653261,60**
INTERMODAL	road	2299,24	1047,02	2518,84	4651,99	70527,41955	109258,97	190303,48
	rail	3155,42	274,43	36119,45	63,45	0	0	39612,75
	barge	3338,72	302,86	0	0	0	288,44	3930,02
	TOTAL	8793,38	1624,31	38638,29	4715,44	70527,41955	109547,41	**233846,25**
UNIMODAL/INTERMODAL		**0,91**	**2,24**	**0,22**	**3,39**	**3,44**	**3,42**	**2,79**

6. CONCLUSION

Intermodal transport has gained interest over the past years and governments take more and more action to promote intermodal transport. An obstacle for many companies however to shift to intermodal transport is the fact that unimodal road transport is often cheaper than intermodal transport. This paper shows that is can be strategically interesting for a company to transport its goods by intermodal transport. A feasibility for the company Colruyt showed that both in the case with subsidies of the government as in the case without subsidies, its more advantageous to use intermodal transport for a part of its commodity flows. The LAMBIT-model showed that the barge terminal of Brussels is the optimal terminal for the DC of Halle, both in the scenario with and without inland waterway subsidies. On the other hand the DC of Ghislenghien falls in neither of both scenarios in the market area of an intermodal terminal, transport by road is the cheapest transport mode, followed by train and then by barge. In the scenario with inland waterway subsidies road transport is still the most attractive option, followed by barge and then by rail. An analysis of the external costs shows that intermodal transport has a lot of advantages to offer compared to unimodal road transport. Only for the category noise intermodal transport, particularly rail transport, encounters disadvantage compared to unimodal transport. When a dieseltrain is used unimodal transport is also more advantageous for the category air pollution. Concluding it can be stated that it can be rewarding for a company to look into the option of intermodal transport as an alternative transport mode for the transport of certain goods. Colruyt has started to use intermodal transport, particularly inland waterways, since the summer of 2009. The containers are brought by barge to the terminal of Brussels (CFNR) from where they are

transported to the distribution center of Ghislenghien by truck. Yearly they use 1000 trucks, accounting for 90% of their container traffic, less than when they only used road transport. This can be translated in an external costs saving of 30 ton CO_2.

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