THE EURO TERMINAL MODEL: AN ANALYSIS OF INTERMODAL RAIL FREIGHT TRANSPORT IN EUROPE

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ABSTRACT

Intermodal transport, the combination and integration of several transport modes with the use of loading units, is in most cases more environmentally friendly than unimodal road transport for the carriage of goods. Intermodal transport offers a competitive advantage to unimodal road transport for longer distances. Looking at the maritime-based inland flows, intermodal transport is an important tool to decongest the port area which has to deal with an ever increasing flow of containers to be handled and transported to the hinterland. Decision makers in Europe are introducing policy measures to promote intermodal transport. In order to see the current situation of intermodal transport and its potentials a broad geographical perspective has to be taken. In this paper we aim to analyse intermodal rail freight transport in Europe with the Euro Terminal Model. The Euro Terminal Model is based on the LAMBIT (Location Analysis Model for Belgian Intermodal Terminals) methodology which has been developed to analyse the market areas of intermodal terminals and potential ones within Belgium. In the LAMBIT methodology, intermodal chains can be compared to unimodal road transport within Belgium. In this paper with the Euro Terminal Model we extend the geographical scope of the model from Belgium to the European level. The model is used within the project Twin hub network (Intermodal rail freight Twin hub Northwest-Europe).

Keywords: intermodal transport, intermodal terminals, gis-model

INTRODUCTION

Intermodal transport is the combination of at least two modes of transport in a single transport chain, without a change of loading unit for the goods, with most of the route travelled by rail, inland waterway or ocean-going vessel, and with the shortest possible final journey by road (Eurostat, ITF, UNECE (2009)). Intermodal transport includes a variety of transport modes like shortsea shipping, inland waterway, rail and road transport. Road transport is used for the pre - and post - haulage. In this paper, the main focus is on international rail/road intermodal transportation in maritime chains using containers as loading units.

Intermodal transport has the unique characteristic of performing transport operations as single integrated processes, where transhipment time and costs are substantially reduced through an extensive standardisation of the loading unit. Given the growing volumes of maritime containers transhipped, the seaports represent an ideal starting point to stimulate intermodal transport. Development of intermodal transport not only enables an extension of the hinterland potential of seaports but also contributes to improving the efficiency of the transport system. Therefore, combination of the strengths of the transport modes presents opportunities to build integrated intermodal transport systems.

Over the past thirty years, a significant growth in freight transport has been sustained in Europe, mainly parallel to its economic growth. Beuthe (2007) points to this long-term evolution of European freight transport in tonne-kilometres, which shows a modest increase of inland waterway and vigorous growth of both continental shortsea shipping and road transport while railway volumes decrease.

Intermodal rail transport presents opportunities mainly for intermodal rail operators and seaport authorities. Despite its potential, only 5 percent of total freight in Europe is done by intermodal transport (Savy, 2007). Representing only a small portion of the total freight transport, intermodal transport takes up an important share within specific corridors, particularly in the North-South corridor (Alpine traffic for rail transport) and the modal split in the seaports. Serving mainly international routes (60 percent), intermodal transport constitutes a market for niches.

Intermodal transport offers a competitive advantage to unimodal road transport for longer distances. Looking at the maritime-based inland flows, intermodal transport is an important tool to decongest the port area which has to deal with an ever increasing flow of containers to be handled and transported to the hinterland. Decision makers in Europe are introducing policy measures to promote intermodal transport. In order to see the current situation of intermodal transport and its potentials a broad geographical perspective has to be taken. In this paper we aim to analyse intermodal rail freight transport in Europe with the Euro Terminal Model. The Euro Terminal Model is based on the LAMBIT (Location Analysis Model for Belgian Intermodal Terminals) methodology which has been developed to analyse the market areas of intermodal terminals and potential ones. In the LAMBIT methodology, intermodal chains can be compared to unimodal road transport within Belgium. In this paper with the Euro Terminal Model we extend the geographical scope of the model from Belgium to the European level within the project Twin hub network (Intermodal rail freight Twin hub Northwest-Europe).

This paper is composed of five sections including the introduction. The second section will introduce the Twin hub network, describing its background and project development. Third section explains the Euro Terminal Model within the framework of Twin hub network. Then two cases will be presented. Finally the paper will end with conclusions.

TWIN HUB NETWORK

Background

It is accepted that the increasing level of containerisation and the changing attitude towards green transport systems can lead to positive perspectives for the further growth of intermodal transport (Kreutzberger, Macharis and Woxenius, 2006). A great concern in this setting is the number of challenges intermodal transport is facing such as to maintain the further integration into the transport networks and to compete with the flexibility of road transport. Acknowledging the role rail freight transport plays in building and maintaining competitive and sustainable European transport system, European policy makers are introducing various policy measures to the rail sector. As discussed in the introduction, however, rail freight transport (the classical rail products) is losing market shares. Intermodal rail transport can be used to revitalise the rail sector but its growth is smaller than needed.

There are various challenges for intermodal rail transport that is hindering its market share. A first one is infrastructure related (Kreutzberger and Konings, 2012). There is lack of rail capacity in connecting seaports to hinterland regions. Capacity problem is seen not only in the port but also at the rail terminals, resulting in delays and long dwell times. Furthermore co-ordination problems are observed due to the activity of many rail operators in serving various rail terminals in the port regions. These have a direct effect on the efficiency of handlings. Finally transport volumes also play an important role as running a freight train requires substantial volumes at an acceptable frequency level. Overall these challenges result in lower intermodal quality in services (low speed) and in uncompetitive cost performances. Administrative burdens and bad image also are considered as weaknesses of intermodal rail transport.

There is a need for innovative rail concepts and collaborations between actors to offer competitive intermodal rail services. The Twin Hub project is formulated to substantially increase intermodal performance by the introduction of such innovative train services through a cooperation of competitors (intermodal operators and seaports). The project partners also include universities and consultants.

The Twin hub network project aims to make intermodal rail transport within, to and from North West Europe more competitive, in particular between the Dutch and the Belgian seaports and European inland terminals. In this way the conditions are created to shift flows from the road to the rail sector, providing a more sustainable and robust transport network and increasing the network connectivity, service frequency and territorial cohesion within North West Europe.

The project is built upon four phases where work is centred on developing a pilot to demonstrate the Twin hub network. In the first phase promising Twin hub service networks are identified to initiate the pilot in the second. In parallel to the pilot, long-term infrastructure needs in the hub locations will be examined. Following the completion of the pilot a social cost benefit analysis will be performed.

Identification of promising Twin hub networks

As discussed in previous section intermodal rail transport requires freight volumes to initiate profitable and frequent services. Unlike road transport this difficult challenge requires innovative organisation in the transport chain. With the Twin hub project container bundling in a hub-spoke service network is used (See figure 1).

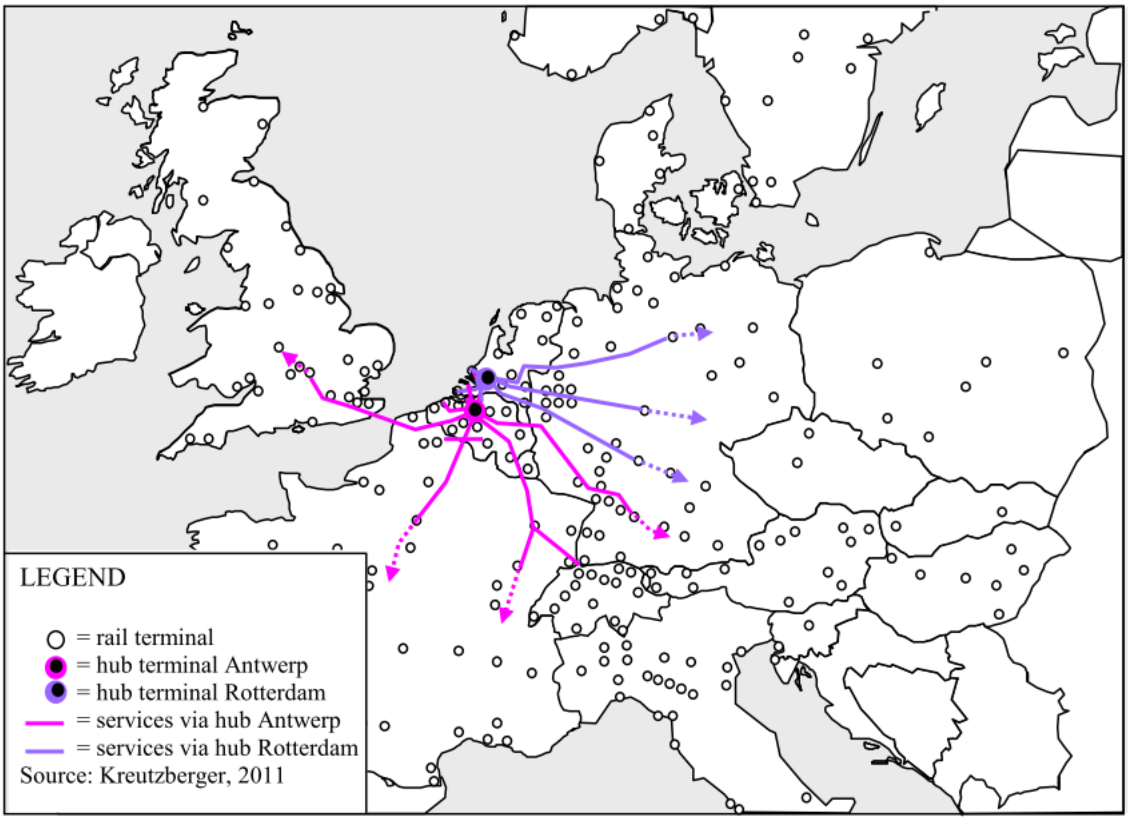


Figure 1: The Twin hub network

Source: Kreutzberger, 2011

In order to design the Twin hub network, a transport flow analysis is performed in WP 1. This analysis is based on mapping road container transport flows. The geographic scope of the freight flow analysis is ranging from the two seaport regions in Rotterdam and Antwerp to the hinterland regions in Europe. The analysis is extended with considering the flows from UK.

The analysis is used as a reference to locate the hinterland regions where new rail services could be established between one of the seaports thanks to bundling. Criteria for promising volume are:

- Total joint annual volume between the seaport(s) and regions exceeds 20.000 TEU
- Joint annual volume in one direction exceed 6.500 TEU

It should be noted that the transport flow analysis is indicating a total potential a promising hinterland region can attract with the rail services. Transport flow analysis is coupled with a detailed cost comparison analysis, where door-to-door transport prices of road and rail transport are compared. As a third step, modal shift analysis is performed to highlight market areas of intermodal terminals in the hinterland regions. Throughout the identification process each step is consulted by the railway operators.

The following routes (hinterland regions) are preliminarily identified as promising regions for the pilot:

- Slaskie region (Poland)
- Basel region (France, Germany, Switzerland)
- Genk region (Belgium)

This paper is about the first phase of the Twin Hub project, namely on the promising Twin hub routes. The paper will present initial results from the modal shift analysis for the selected routes. This analysis is carried out by the Euro Terminal Model, which is based on the LAMBIT methodology therefore below the methodology will be explained.

METHODOLOGY

The LAMBIT methodology

The LAMBIT (Location Analysis Model for Belgian Intermodal Terminals) methodology (Macharis 2000 and Macharis and Pekin 2009) is extended and applied to the location analysis of intermodal rail terminals for the Twin hub promising routes. In this section the Euro Terminal Model that is used to assess the modal shift of the promising Twin hub networks is explained.

Within the LAMBIT methodology three major components can be identified (see figure 2). The first component in the model is its inputs, with all sorts of data to be included in the analysis. The second component is the core model, a GIS (Geographic Information Systems)-based intermodal transport model, which performs analysis of policy measures. The GIS provides output, which constitutes the third component of the model such as maps with the market area of the terminals.

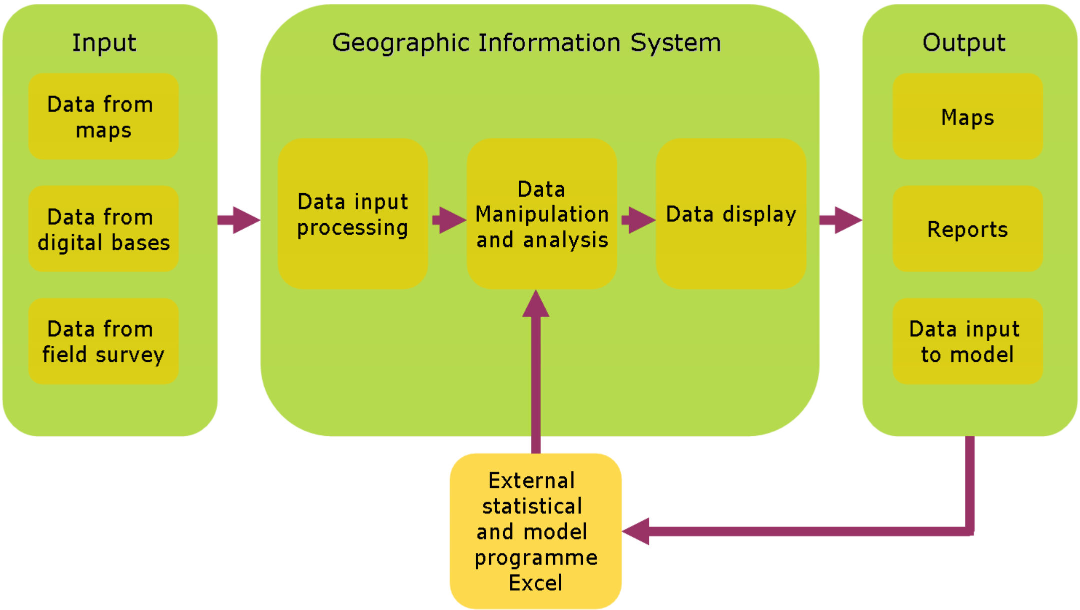
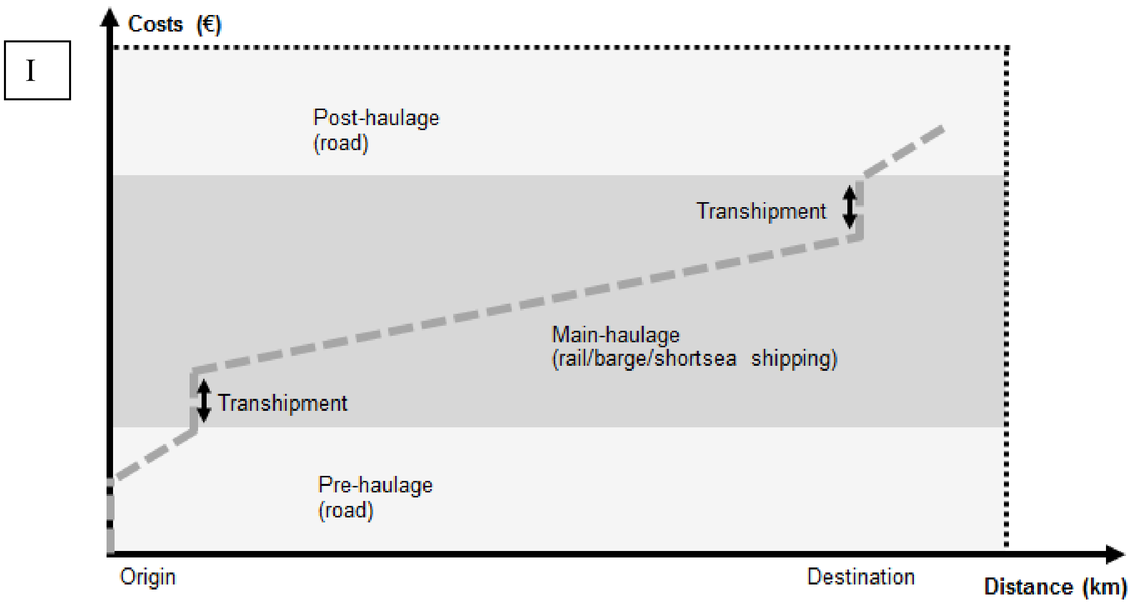


Figure 2: Architecture of the LAMBIT model

Source: Pekin, 2010 based on Fischer and Nijkamp, 1993

Utilising the intermodal cost function, the methodology performs a price (cost) minimisation approach. Figure 3 presents an intermodal cost function. For a door-to-door intermodal transport chain, the function allows to calculate total intermodal transport costs between an origin and a destination. Pre – and post – haulage requires interchanges from road transport to another transport mode in an intermodal terminal. In the upper part (I), the incurred costs are inserted chronologically, starting from loading for pre haulage, transhipment, main haulage, another transhipment, and, finally, end haulage. Note the comparatively steep inclination indicating a high cost per kilometre for the post-haulage by road. From the figure, it is possible to derive the importance of transhipments in an intermodal transport chain. An example in the Twin hub network is hub operations.



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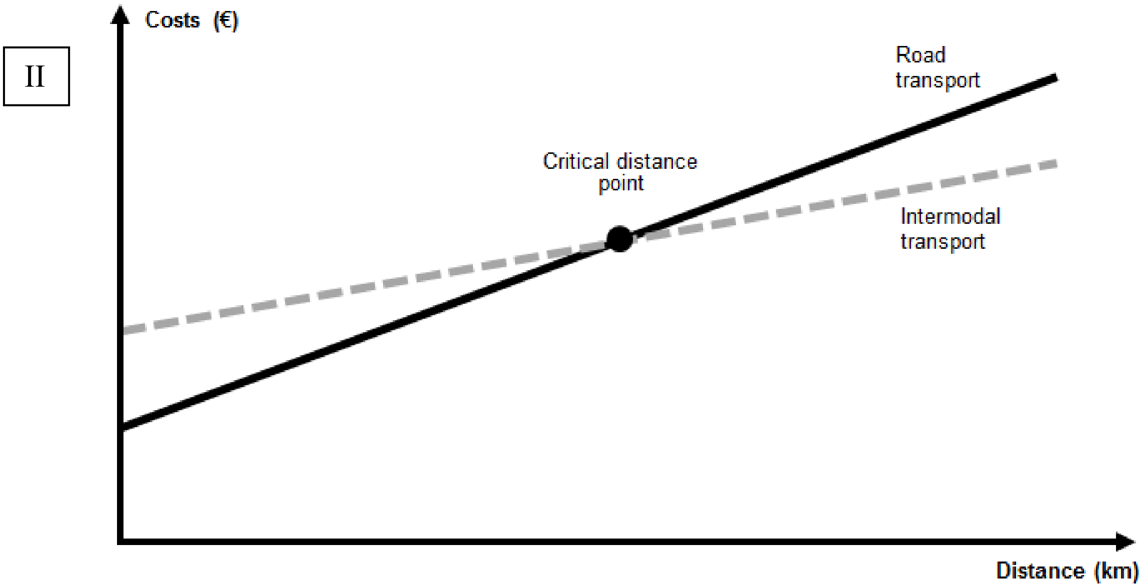

Figure 3: Intermodal cost function

Source: own setup, 2013

In the lower part (II), all extra costs of transhipment and pre- and end haulage have been added from the start. Inserting a cost curve for unimodal road transport that is steeper due to the higher variable cost then allows for finding the critical distance point where unimodal road and intermodal freight transport is equally costly. Above that distance, intermodal transport is competitive from a cost perspective.

Within the Twin hub concept, intermodal rail transport incurs larger handling costs compared to unimodal road transport. This is due to the extensive bundling operations that are used for the transhipment of containers on rail wagons. The main haulage is carried by rail. The advantage of intermodal transport lies in the smaller variable costs during main haulage, which are the result of the scale economies that are obtained by the large capacities that can be transported. As the variable costs of rail transport is cheaper compared to unimodal road transport, longer distance covered by the intermodal leg will make intermodal transport more efficient than unimodal road transport. However, at the end of the chain, an extra handling cost is incurred for the handling at the terminal in the hinterland.

The break-even distance reacts to the changes in the cost components of road and intermodal transport. The lines will move downward if the fixed costs decrease. For example, a decrease in the dues for intermodal transport would shift the dotted line downwards and reduce the break-even distance. The slope of the lines reacts to the changes in the variable costs. For example, an increase in fuel price would affect the variable cost of both unimodal road and intermodal transport. It will make the gray line steeper, shifting the break-even point to the left. Intermodal transport becomes more competitive, but this is tempered to some degree as the cost of pre- and post-haulage also rises.

Studies have been commissioned to analyse the break-even distances. In 1994, the Dutch Ministry of Transport calculated break-even distances of 100-250 kilometres for inland navigation and 200-400 kilometres for railways (Van Duin, 2003). At a European scale, intermodal services over 600 kilo-metres are usually proven to be viable, while services over distances of 100 kilometres can rarely compete with unimodal road transport (Vrenken et al., 2005). Other cost factors such as empty container depot functioning of an intermodal terminal, congestion, and the distance of pre/post haulage will have also an impact on the break-even distances and will in reality lower the ones that are mentioned above. In section 3 break-even analyses will be performed for the Twin hub network routes.

Model extension

LAMBIT is based on three main inputs: transportation networks, transport price functions, and demand for transport of containers from the regions to and from the sea ports. The design of the model and its extension towards an Euro Terminal Model are described in this section.

Transportation networks

Geographical scope of LAMBIT was extended by the European intermodal network layers. The model has been built through connecting the geographic locations of the intermodal rail terminals (transhipment points) and the NUTS3 regions (end destinations) to the road and rail network layers by their corresponding nodes. During the set up process, possible Twin hub locations such as the Main Hub in Antwerp and RSC in Rotterdam are also included. Figure 4 depicts the layers of the network.

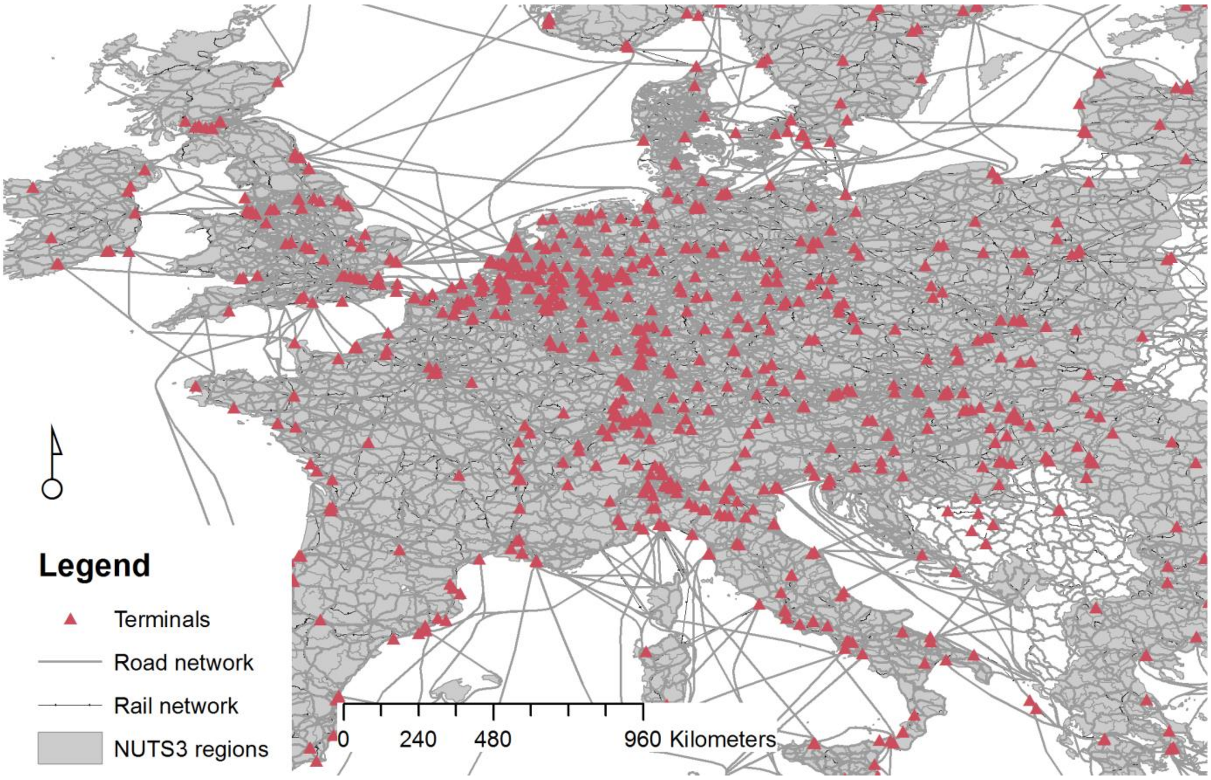

Figure 4: Network layers and nodes

Source: own setup, 2013

The Twin hub GIS network was built by merging the following digital databases:

- NUTS 3 region layers are obtained from Geographic Information System of the European Commission (GISCO).
- Road network and terminal location layers are obtained from the ETISplus database.
- Rail network layers are extracted from the ESRI (Environmental Systems Research Institute) dataset for Europe.

Transportation prices

In the second step of the model extension, an intermodal cost structure is developed to be used in break-even analysis, which is the concept behind the LAMBIT methodology. Considering the total transport prices and the distance travelled, unimodal road transport is cheaper over short distances, but once the breakeven distance is achieved, intermodal rail transport offers a competitive alternative.

In the model, the following formula is used to calculate total intermodal rail costs:

$$TC = ((T \div (FF \times C)) \times D + W + H + O$$

where T is the traction (Euro per train kilometre) of the rail operators. In order to calculate the rate per TEU kilometre, fulfilment (FF) of the trains and their nominal capacity (C) are also considered. Here an assumption of 75% FF for trains of 85 TEU with nominal length capacity of 600 meters is made. Once the rate per TEU kilometre is calculated, this variable cost is multiplied by (D) rail distance (kilometres). Then two fixed costs wagon costs (W) and handlings (H) are added. Both of these cost components are expressed as Euro per TEU and incurred in the Twin hub and inland rail terminals. Finally the overhead (O) of 15% is coupled to arrive at the total intermodal rail cost.

For road transport (both for unimodal and pre - and post – haulage), fixed price and variable price functions are based on the existing market prices. For each region of the Twin hub network a separate price function is inserted. The calculated total transport prices for each transport mode are then associated with the network layers. The variable prices are uploaded to the network layers, and the fixed prices are attached to the nodes, which also indicate the origin and destination for each route and to the intermodal terminals in case of an intermodal trajectory.

Project partners (intermodal rail operators) are consulted to obtain data for the model. In order to have reliable transport prices average market prices were calculated. The assumption is that costs are included in these prices.

Container flows

Another input for the model is the transport demand in terms of container flows to and from the port regions of Antwerp and Rotterdam. In the framework of the first phase of the Twin hub project, data from the European ETIS project that is processed by Pantheia (NEA) and analysed by Delft University of Technology (OTB) is used. Within the scope of Euro Terminal Model, only containers from/to the port regions of Antwerp and Rotterdam and from/to each NUTS3 region have been extracted and attached to the NUTS3 database.

Model operation

The model explores the relative attractiveness of two transportation modes (unimodal road and rail transport) through a price (cost) minimisation model. In the model, the total sum of transport prices is minimised. Using a shortest path algorithm in ArcInfo, various scenarios are conducted in order to find the shortest path and the attached transport prices from the Twin hub (Port of Antwerp or Rotterdam) to each NUTS3 region via intermodal terminals and via unimodal road. For each destination, the total transport prices for unimodal road and rail/road transport are compared, and the cheapest option is selected. The market area of each inland terminal is then highlighted in the map of the model. These visualisations make it possible to see how large the market area of each intermodal terminal is. As a further step, the container flows data are 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.

TWIN HUB CASES

The Twin Hub network offers international long distance direct train services for ports of Rotterdam and Antwerp. As explained in section 2, intermodal operators cooperating with traction providers will connects the ports of Rotterdam and Antwerp with European hinterland regions through the Twin hub network. This paper focuses on two cases of the Twin hub pilot network: Slaskie (Poland) and Weil am Rhein (Switzerland) routes. For each case, an audit of the intermodal rail transport market will be made. Then results of the Euro Terminal Model analysis will be discussed.

Slaskie case

Poland is mainly connected to Europe by a road network. Polish companies control the largest truck fleet in the EU. Taking 1996 as a reference, market share of intermodal rail transport increased from 0,7% to 1,1% in 2000 and to 1,7% in 2005. These figures indicate that intermodal rail transport still accounts for only a marginal part of the railway operations. Container transportation is the fastest growing transport segment in Poland. In 2005, 800.000 TEU were transported to/from in Poland. Polish seaports of Gdynia, Gdansk and Szczecin play an important role in this traffic. 56% of the container traffic is connected to the hinterland transport and is realised mainly by trucks. 44% of the container traffic is cross-border, originated from the European seaports of Hamburg, Bremerhaven and Rotterdam. Here, road and rail transportation have about 50% share.

Market leader in cross-border rail transportation of containers is Polzug Intermodal GmbH, a joint venture equally owned by PKP Cargo, Stinnes AG and HHLA Hamburg Port and Logistics AG. Main business of Polzug Intermodal is to offer hinterland transport services from North Sea ports to/from Poland. Polzug Intermodal connects Poland (via eight Polish terminals) with Hamburg, Bremerhaven and Rotterdam. In 2011 the production system of Polzug has been changed to a “hub concept” (UIRR, 2011). A new terminal in Poznan serves as the hub, where shuttle trains with multi-system locomotives are connected. This system aims to reduce the transit times to offer fast and reliable rail transport. Transit time for Hamburg-Poznan is now 12 hours without border stopping. Additionally, Polzug Intermodal is replacing old terminals by modern ones. In 2008 the terminal in Wroclaw was opened. This is followed by Dabrowa Gornicza in 2010 and the hub in Poznan in 2011. In 2013 Brwinow is foreseen to be opened near Warsaw.

Other railway operators are found in the market serving the Twin Hub network routes with their own products. For the Polish market from the port of Antwerp, Hupac and Kombiverkehr run seven destinations, sometimes directly, sometimes through Duisburg. From the port of Rotterdam Polzug, and Kombiverkehr are competitors.

The market overview above has to be coupled with the freight flow analysis to see if Polish regions have enough potential for initiating intermodal rail transport from the Twin hub seaport regions. Figure 5 show that the Slaskie province has the highest flows. In absolute terms the province accounts for more than 22.000 TEU. When flows from the UK are also integrated the potential increases to reach more than 46.000 TEU. Slaskie province is an industrial region with activities in mining, metallurgy, engineering, chemical, textile and the automotive sector. The province, which is one of the richest in Poland, also has good railway access with the longest so-called broad gauge railway line (the LHS line) in Poland. This line is designed for freight transport only and it connects Poland to Ukraine (LHS, 2013). The second region is Warsaw province, where flows are not reaching the threshold of Twin hub network. The province can have potential only when the flows from the UK are considered. Since there are already frequent rail services from the ports of Antwerp and Rotterdam, this region is not suitable for the Twin hub network.

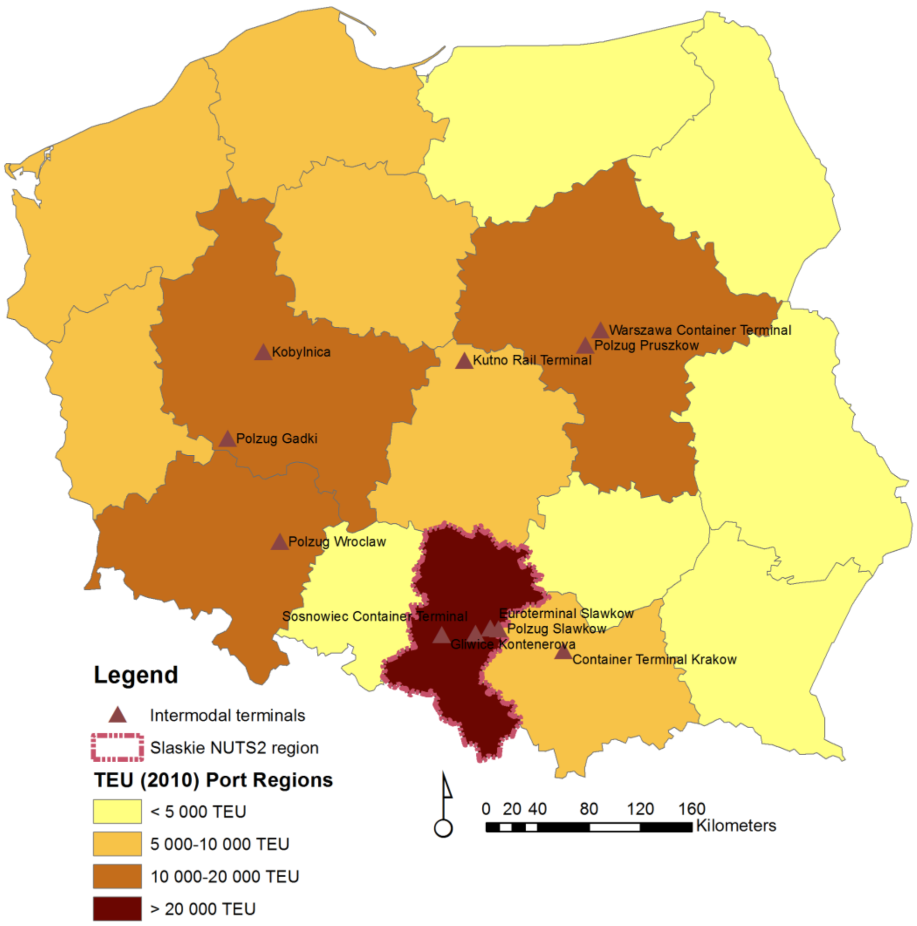

Figure 5: Overview of container flows to Poland

The next step is to investigate possible connections from Twin hub (Mainhub in Antwerp and RSC in Rotterdam) to the hinterland terminals in Slaskie province. Here attention is paid to the services that are already operating in the market as well. Results of the Euro Terminal Model highlight that rail services from RSC are cheaper compared to Mainhub. Considering the hinterland region, the terminal in Sosnowiec is the best option for minimising the post haulage. The market area analysis for Slaskie province is presented in Figure 6. The break-even distance for Slaskie case is 464 kilometres if a shorter post-haulage (20 kilometres) is foreseen. When a longer post-haulage is needed the break-even distance reacts accordingly and increases up to 636 kilometres in the case of 100 kilometres of post-haulage.

The market area of the terminals can be represented as the number of NUTS3 regions that they attract flows. In Slaskie province there are 8 NUTS3 regions. In all of these regions intermodal rail transport is cheaper compared to unimodal road transport. The terminal in Sosnowiec can take 5 NUTS3 regions. The terminal in Gliwice has a share of 3 regions. The third terminal that is located in the province, Slawkow, cannot take any market area. Finally, the terminal in Krakow is also taking area but outside the Slaskie province. Depending on the distance of post-haulage from the terminal, intermodal transport prices increase. This is visualised by lighter shades in the market area in the figure.

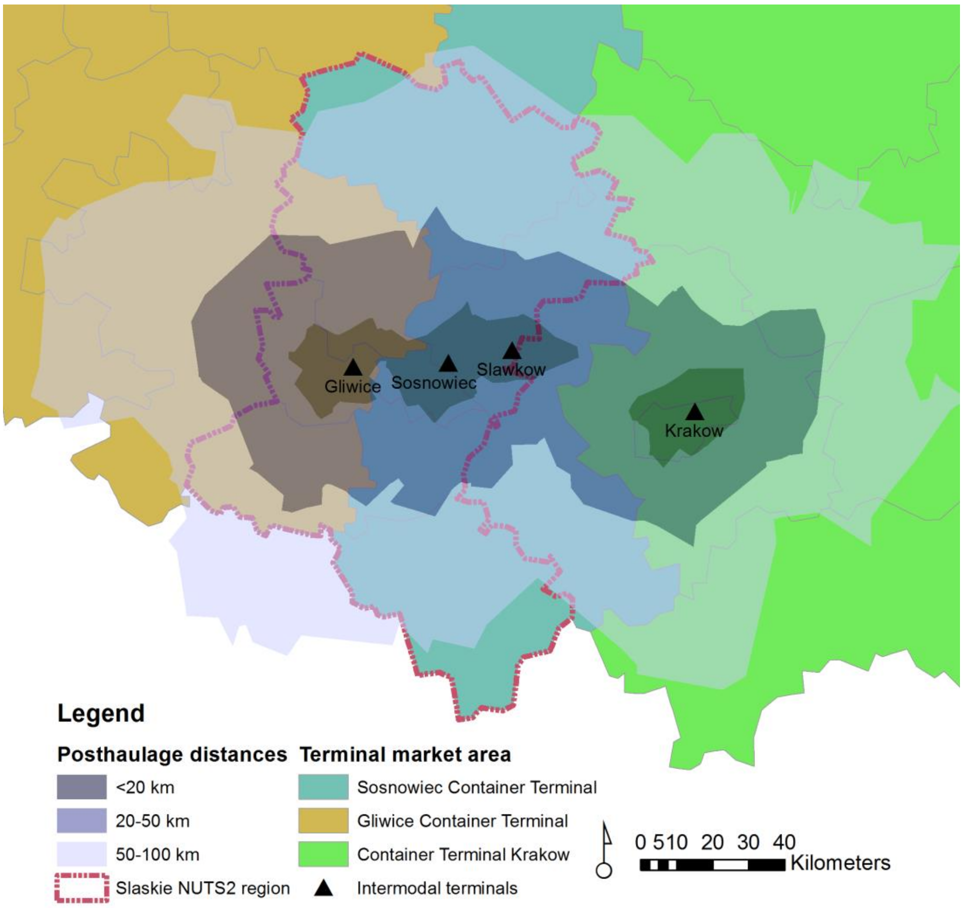

Figure 6: Market area analysis for Slaskie region

Basel case

As an alpine transit country, Switzerland accommodates container flows connecting Northern and Southern Europe in a shortest way. Transalpine freight traffic through the Swiss Alps grew by about 60% between 1994 and 2010 (Mertel, Petri and Sondermann, 2012). Considering the external effects of road transport, Swiss citizens voted to stop unbalanced growth in road freight transport thus construction of transit roads in the Alpine area were no longer accepted. In parallel, policy makers formulated multiple measures to achieve modal shift such as the modernisation of the railway infrastructure (especially the NEAT tunnels), the railway market reform and user (polluter) pays principle. Overall the goal is to improve the competitiveness of the rail freight transport. Positive results are already achieved since 2000. Rail transport started to offer better quality services with higher capacity. Share of rail freight increased to 66% and combined transport share in rail freight increased to 67% (Liechti, 2007). At the same time number of trucks in transit is reduced by 14%.

Examining the Swiss market with intermodal services from the Twin hub port regions, competition is seen especially from the port of Antwerp with IFB, Hupac and Kombiverkehr running trains to Basel. Only Hupac runs to Aarau. These railway operators also have services to the Weil am Rhein terminal which is located on the Swiss-German border, where MSC Medlog also is competing. From the port of Rotterdam Hupac and Kombiverkehr have services to Weil am Rhein.

The first step in performing the Euro Terminal Model analysis is to examine freight flows. The case is situated in the Basel region, specifically in Weil am Rhein in which the Swiss, French and German borders meet. The overview of container flows to Switzerland is provided in figure 7. Here higher flow from the Twin hub port regions is seen in the French Lorraine and Alsace provinces that are located in the northern part of Basel. German province Freiburg also has higher flows compared to Basel itself. Nevertheless economically the neighbouring regions in Germany and France are not separated from the Basel thus real potential can be calculated with the Euro Terminal Model on the market area of intermodal terminals.

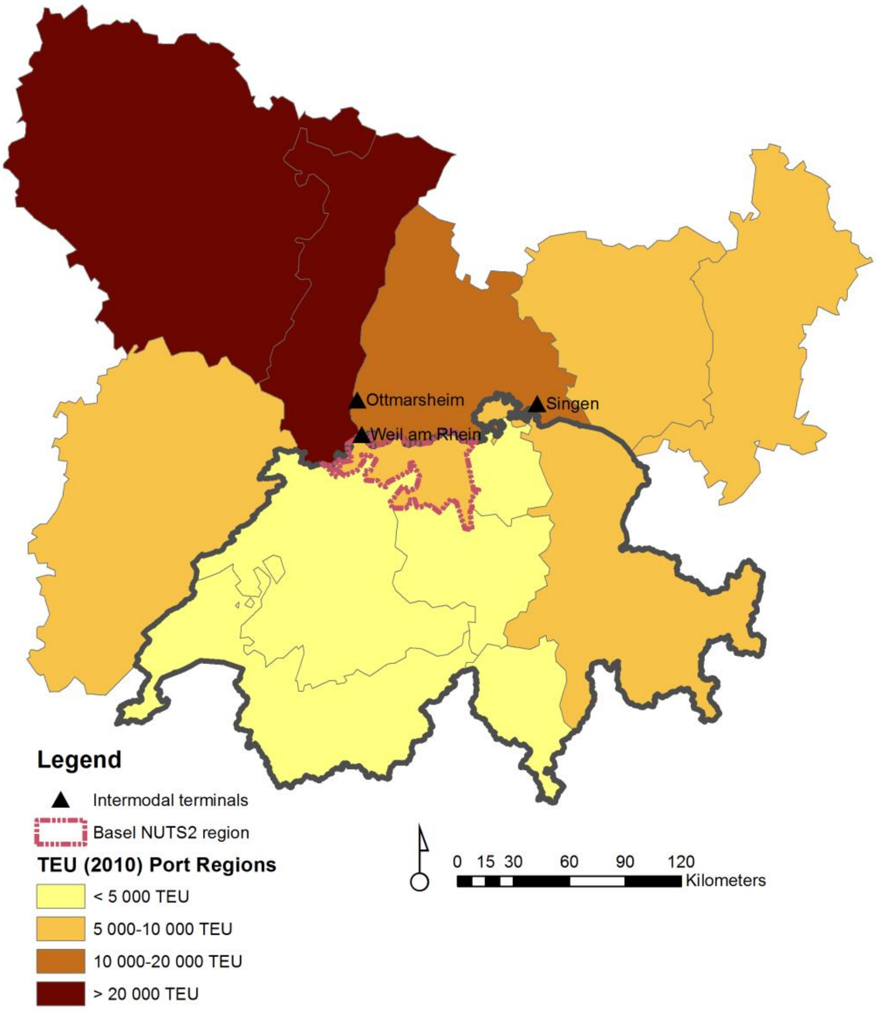

Figure 7: Overview of container flows to Switzerland

In figure 8 the market area for intermodal terminals is examined with the Euro Terminal Model. The model results show that rail services from the Mainhub are cheaper compared to RSC due to shorter rail distances of the port of Antwerp to Basel. In the hinterland region, the terminal in Weil am Rhein can capture whole Switzerland including Basel. The break-even distance for the Basel case is 384 kilometres if a shorter post-haulage (20 kilometres) is foreseen. When a longer post-haulage is needed the break-even distance reacts accordingly and increases up to 527 kilometres in the case of 100 kilometres of post-haulage. Compared to Slaskie case, the break-even is lower. This is explained by the higher road transport prices in Switzerland.

Whole Basel (3 NUTS regions) are in the market area of Weil am Rhein. The terminal also attracts two NUTS3 regions from Germany and one region from France over the Swiss border. Terminal in Ottmarsheim takes area in French NUTS3 regions and terminal in Singen takes German NUTS3 regions. Figure 8 also provides gradual post-haulage distances, with the darker areas near the terminal have cheapest intermodal prices due to shorter post-haulage distances.

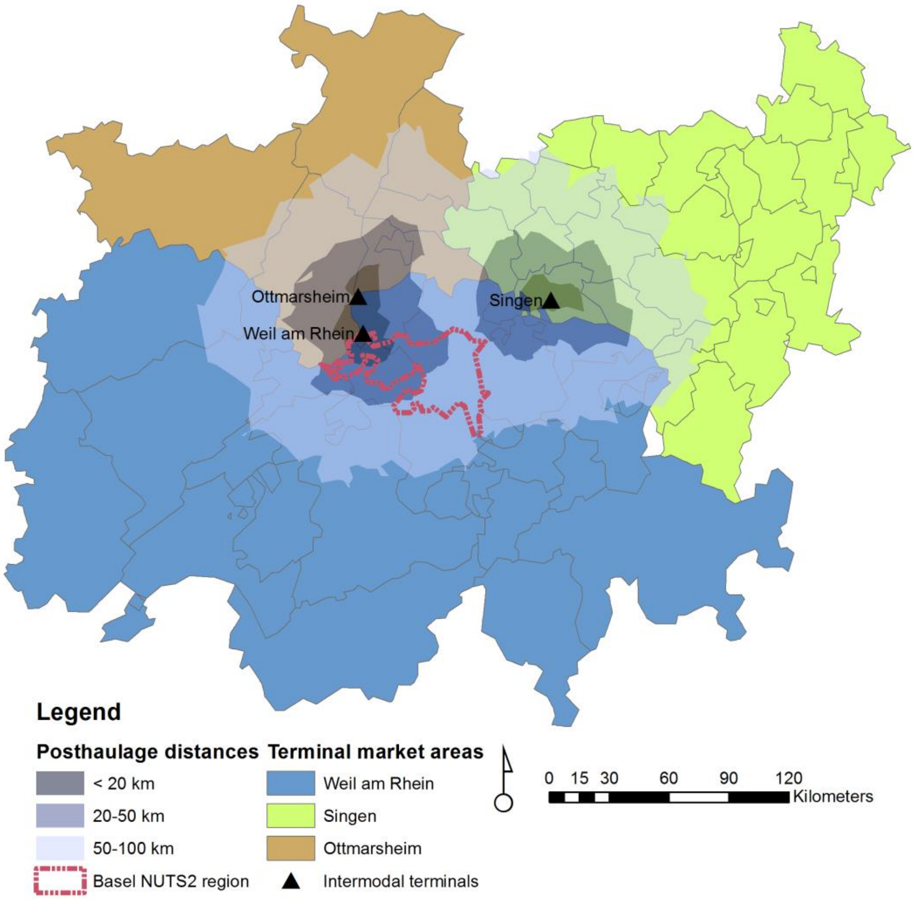

Figure 8: Market area analysis for Basel region

CONCLUSIONS

This paper presents the Euro Terminal Model, which aims to analyse intermodal rail freight transport in Europe. The model is used within the framework of INTERREG project Twin hub network which is a bundling concept for intermodal rail freight flows from the seaports of Antwerp and Rotterdam to the European hinterland regions.

The model is based on the LAMBIT methodology which is scaled on the Belgian intermodal terminal landscape. Within the framework of Twin hub network, the model is extended to the European level. The model compares transport alternatives based on the current market prices for each transport mode. In this paper two cases (Slaskie and Basel) are presented. The results of the Euro Terminal Model indicate that intermodal rail transport can have potentials compared to unimodal road transport due to longer distances where rail transport is competitive. One of the major findings of the analysis is a break-even distance of at least 384 kilometres is needed for rail transport to compete with unimodal road transport. The model also indicated which terminal to use in the hinterland regions. The model can further examine the market area of terminals through scenarios such as the introduction of subsidies and road pricing measures.

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