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Port hinterland connections: a comparative study of Polish and Belgian cases

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Abstract

The study takes a comparative approach by investigating the situation in the hinterlands of two different port areas in Europe: Antwerp (Belgium) and Gdansk-Gdynia agglomeration (Poland). Both port centres have an important road hinterland connection that faces competition from other alternative modes of freight transport. However, the Port of Antwerp is already one of the leading ports of the continent while the ports of Gdansk and Gdynia are at the stage of building their competitive position. In the paper the results for both ports obtained using different methodologies are compared. Existing spatial analogies allow making conclusions that are valid for both environments.

Keywords: hinterland transport; competitive modes; infrastructure; regulation; mode choice; Belgium; Poland; comparative study

1. Introduction

Europe is currently in a situation where the pressure from increasing goods flows rises. The road network is congested during peak hours and on crucial stretches, the rail sector is struggling to increase freight transport capacity, and the existing land based infrastructure cannot readily cope with the increase in traffic volume at the pace at which it is now growing, mainly due to bottlenecks.

Seaports often experience congestion on the land side with road hinterland links usually being more congested than others. In case the *status quo* will be sustained, the situation will continue to worsen as European freight volumes might increase with as much as 50% by the year 2020 (Institute of Shipping Analysis, Göteborg *et al.*, 2006). Optimization of the capacity of these connections seems to impose itself in view of the frequent occurrences

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of congestion on the road links. This problem was widely discussed among others by Van Schijndel and Dinwoodie (2000) and Notteboom (2008). They analyzed closely relationships between ports and transport infrastructure around them. Many other studies also include methods and proposals for improvements in hinterland connections (Konings, 2007; OECD, 2008; Rodriguea *et al*., 2009; Roso *et al*., 2009). Authors suggest for instance such solutions for transportation problems like: increasing role of rail and inland water transport, careful programming of new transport investments, promoting sustainable ways of transportation and improving decision-making process in transportation planning (Nijkamp & Blaas, 1994). In literature on hinterland connections common are optimization models which include intermodal simulations (Pedersen, 2005; Carisa *et al*., 2011) and GIS methods (Macharis & Pekin, 2009).

Both port centres: Antwerp and Gdansk / Gdynia are similar in having an important road hinterland connection that may be balanced by alternative modes of freight transport – railway and inland navigation. The Belgian case is the E313 motorway, which makes the connection between Antwerp and Liège and further on also Germany. The motorway has competition from both rail and inland waterways, especially in dealing with port-bound traffic. As to waterways, the Albert Canal, which runs mainly in parallel with the motorway, is currently being subject to capacity expansion through the extension and elevation of a number bridges that cross the canal. Rail could specifically benefit from the potential re-activation of the Iron Rhine - an almost parallel connection to the motorway E313 between Antwerp and the German Ruhr area.

The Polish case is focused on possible benefits of the mode shift of freight traffic between the Baltic coastal agglomeration of Gdansk-Gdynia, with an important international harbour, and the quickly developing regional centre of Bydgoszcz-Torun. At present, the main connections between those urban areas are the state road No 1 and railway CE-65 – both are elements of the TEN-T network linking Gdansk and Vienna. Gdansk, Torun and Bydgoszcz are also linked with Vistula River. Bydgoszcz is an intersection of two International Waterways (IWW) set in The European Agreement on Main Inland *Waterways* of International Importance (*AGN*) - E 40 and E 70. The analyzed section of the Vistula River coincides with the course of both IWW, however it is better known as part of IWW E 70. So far the IWW E 70 has marginal importance. This is because it has only class II, while it is necessary to reach at least IV class to make inland waterway transport fully competitive against other modes of transport (Marshal Office of the Pomorskie Voivodeship, 2010).

The existing freight market situation will soon change as the ports of Gdansk and Gdynia are being developed and the A1 motorway linking Gdansk and Torun is planned to be finished by the end of 2011. An important issue in this case is whether the waterway has a chance of becoming competitive to road and the railway system.

A change in approach to the role of the inland waterway transport system in Poland is necessary to achieve the desired effect of revitalization of the IWW E 70. This requires the political will and public acceptance (Bolt, 2010). The future development of freight water transport in Poland is dependent on many factors, but one of the most important are cost savings.

2. Case of Antwerp

2.1. Preface

For the Antwerp case, we analyse the situation of the E313 motorway, which is approximately 120 kilometres long. It connects Antwerp to Liège and is a link to the Ruhr area in Germany, as can be seen in Figure 1 . For most of its length, it has two lanes in each direction. The Port of Antwerp, the second largest port in Europe for international freight shipping, is one of the main generators of heavy goods vehicle traffic for the E313 route. Data for recent years shows that around 40% of all goods flows of the Port of Antwerp are transported to and from the port by road.

The motorway features particular competition from both rail and inland waterways, especially in dealing with port-bound traffic. As to waterways, the Albert Canal, which runs mainly in parallel with the motorway, is currently being subject to capacity expansion through the extension and elevation of a number of bridges that cross the canal. From the rail side, the Iron Rhine is a potential competitor of the E313 motorway. It is the historic railway line, started up in 1879, that runs from Antwerp to the German Ruhr area. Since 1991, this track is no longer used for international transport. Nowadays, the so-called Montzen route is used, which makes a detour over Liège. The

Belgian Government has stated its intention to resume and intensify the use of the Iron Rhine railway line. Restoration, alteration and modernization, referred to as "reactivation", of the Iron Rhine route will therefore be required. Both Iron Rhine and Albert canal are part of the TEN-T network. The Iron Rhine falls within rail axis nr. 24 (Lyon/Genova-Basel-Duisburg-Rotterdam/Antwerp), whereas the Albert Canal is part of axis nr. 18 (Rhine/Meuse-Main-Danube).

Capacity optimization seems to impose itself here, in view of the motorway featuring frequent occurrence of congestion and the many accidents. The severity of the problem shows up also in a survey held among Flemish road transport companies (Gevaers, *et al.*, 2009). On the other hand, a number of more general capacity optimization measures are being put in place by the European Commission but more importantly also by the Flemish government. The latter also deploys a mode shift strategy, with the aim of increasing the chances of both inland navigation and rail transport.

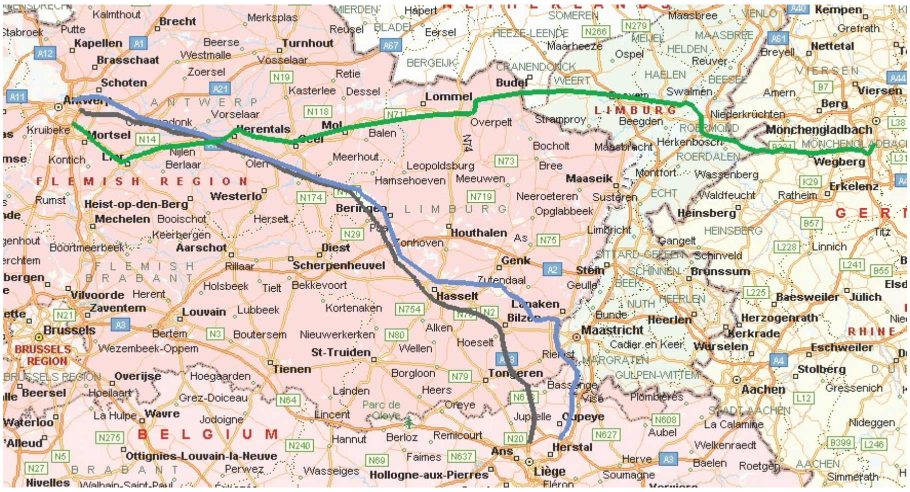

Figure 2 Motorway E313 (grey), Iron Rhine (green) and Albert Canal (blue). Map source: Microsoft MapPoint 2009

2.2. Methodology

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

Based on the findings from the impact analysis, a link was made between the selected influencing factors and scenarios in the Freight Model Flanders. Several scenarios were built to construct a min-max range that describes assumptions on possible developments, which are dealing with the economy, policy, population and household consumption, imports and exports, and inland ports. Modelling a reference scenario and 12 alternative scenarios for the year 2020 was done with the Freight Model Flanders. A three-level approach was adopted to interpret the simulation results. At the first level, total tonnages were calculated and figures were evaluated for every scenario. At the second level, route change investigation was done by interpreting a difference plot. At the third level, mode shift effects were investigated.

2.3. Freight model and simulation results

Commissioned by the Flemish Traffic Centre (Vlaams Verkeerscentrum), freight model for Flanders has been developed by K+P Transport Consultants, Tritel and Mint. Based on the freight model, it is possible to simulate future freight flows, split up by mode (road, rail and inland waterways) and NST freight category. A classical 4-step model has been used:

- Generation of flows: determines the flows leaving from (or arriving in) zone *i (j)* in a period. For freight transport, this means that for freight category k it is calculated how many tons are leaving from (arriving in) zone *i (j)*;
- Distribution of flows: the generation of flows serves as input for this stage. The freight flows are determined between zones i and j;
- Mode choice: analyses which mode is used to move tons from zone *i* to *j*;
- Assignment: comprises route choice, after translating the tonnages into number of vehicles in a traffic conversion section.

Transport Logistic Nodes (TLN) are also included in the model. A TLN zone is a transfer point where loads change the means of transport, which is not necessarily the mode, simultaneously with a re-consolidation of the shipment. The Freight Model Flanders takes into account the so-called decided infrastructure changes of the Flemish government.

2.3.1. Scenarios

A number of purpose-made scenarios have been constructed (see Table 1). The scenarios are based on possible developments in the economy, as well as on possible policy that could be introduced by the government. Each scenario is a combination of several assumptions: economic, policy-related, linked to population and household consumption, dealing with import and export, and with inland navigation and ports. The details on the specific underlying assumptions for these scenarios can be found in Aronietis *et al.* (2010).

Table 1 Scenarios

Scenario	Economic assumptions; assumptions for import and export	Policy assumptions	Assumptions for inland navigation	Port assumptions
1	Low growth	Continuation of current policy	Continuation of current policy	Following economic assumptions
2	Low growth	Continuation of current policy	Extra measure inland navigation	Following economic assumptions
Reference scenario	Normal growth	Continuation of current policy	Continuation of current policy	Following economic assumptions
3	Normal growth	Continuation of current policy	Extra measure inland navigation	Following economic assumptions
4	Normal growth	Moderate transport policy	Continuation of current policy	Following economic assumptions
5	Normal growth	Moderate transport policy	Extra measure inland navigation	Following economic assumptions
6	High growth	Moderate transport policy	Continuation of current policy	Following economic assumptions
7	High growth	Moderate transport policy	Extra measure inland navigation	Following economic assumptions
8	Normal growth	Internalizing external costs of all modes	Continuation of current policy	Following economic assumptions
9	Normal growth	Continuation of current policy	Continuation of current policy	0.5 x results economic assumptions
10	Normal growth	Continuation of current policy	Continuation of current policy	1.5 x results economic assumptions
11	Normal growth	Internalizing external costs of all modes	Continuation of current policy	0.5 x results economic assumptions
12	Normal growth	Internalizing external costs of all modes	Continuation of current policy	1.5 x results economic assumptions

2.3.2. Simulation results

A three-level approach has been adopted to interpret the simulations results. The full simulation results themselves are available in the report by Aronietis *et al.* (2009). Three types of output were produced:

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

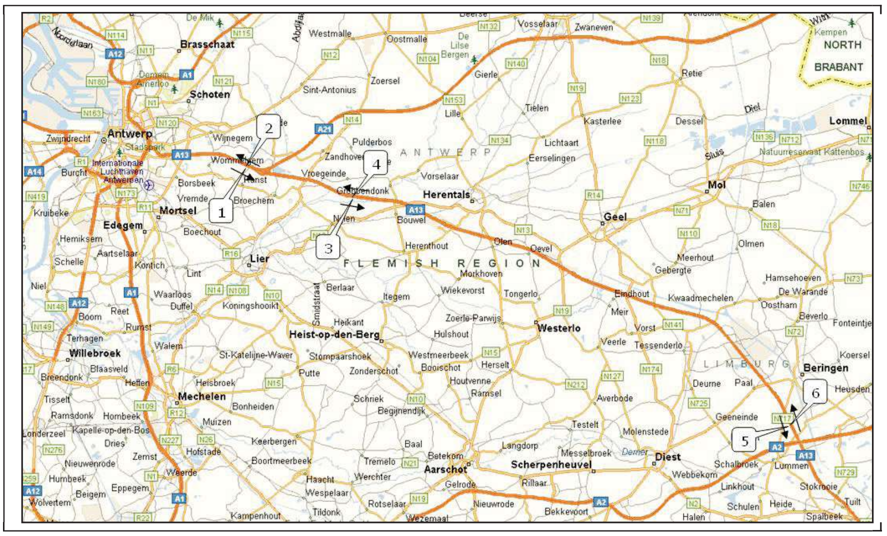

Figure 3 Measurement locations on the E313/A13 motorway. Map source: Microsoft MapPoint 2009.

In all simulation results, the base year is 2004, while tonnages in the scenarios refer to 2020. Results of the first type of output refer to specific locations on the E313, as illustrated in

Figure 3. In particular, locations 1 and 2 are close to Antwerp and are selected to illustrate the direct effect of the port of Antwerp. Locations 3 and 4 are selected in order to give a view on the tonnages after the split between the E313 and E34. Finally, locations 5 and 6 are important because they are located in the vicinity of the intersection Lummen (E313 and E314).

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

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

- Red lines show an increase of more than one hundred tons;
- Green lines show a decrease of more than one hundred tons;
- Grey lines show minor differences, indicating that the scenarios have an insignificant effect on the tonnages transported on the specific network link.

On the other hand, the thickness of the lines represents the volume of tonnages for each link. An example of a difference plot output is presented in Figure 3.

As the third type of output, a mode shift analysis was done. Four regions were selected to analyze the mode shift effects of the scenarios: the port of Antwerp, the county of Antwerp (excl. Port of Antwerp), the Turnhout region and the Hasselt region. For each region, the total incoming and outgoing flows in tonnage have been calculated for road, rail and inland waterways. This enabled the calculation of the mode split for the base year 2004, the reference scenario and the specific scenarios for the year 2020.

Based on the three-level approach that has been adopted to interpret the simulation results, a list of observations was made. Those are reported in detail in Aronietis *et al.* (2010).

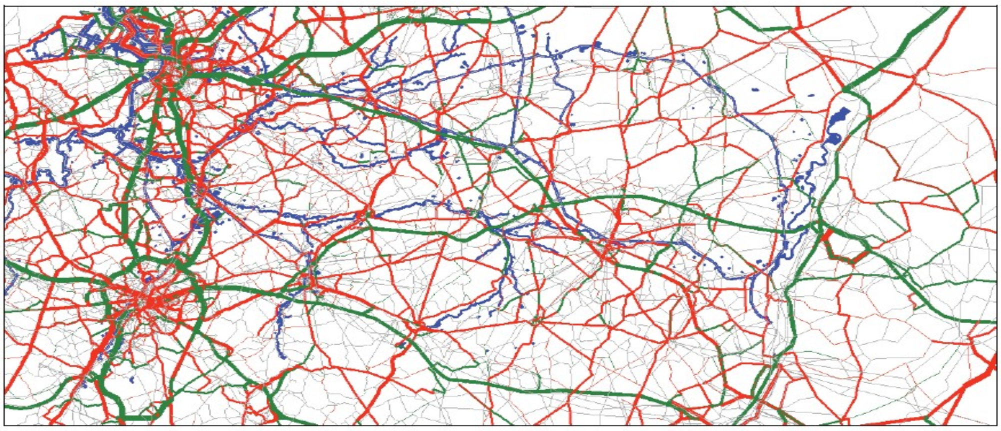

Figure 4 Scenario 4 versus reference scenario. Source: Own composition based on Freight model Flanders

3. Gdansk-Gdynia case

3.1. Preface

In the Gdansk-Gdynia case we analyse a fast growing port centre which has connections with the Bydgoszcz Inland Junction, which is located 160 km away. The connections used currently are road network and railway. However, it is also the possible to create a waterway along the northern part of the Vistula River. Considering the period 2000-2009, the annual reloading volume in the analyzed port agglomeration has risen by the following: Gdansk 14% and Gdynia 54% (Actia Forum, 2010). The fastest growing type of freight is the containers. The Port of Gdynia's Baltic Container Terminal (BCT) has a current annual handling capacity of some 750.000 TEUs, and a potential capacity of 1.200.000 TEUs. In 2007 reached the result of 493.860 TEUs (BCT, 2010). The Deepwater Container Terminal (DCT) Gdansk is currently the fastest growing terminal in the country. In November 2009, Gdansk became a hub, because one of the largest container operators (Maersk) opened a regular line to Shanghai. In the first half of 2010, container throughput was higher than in the whole year 2009 – reaching the reload volume of 173.279 TEUs. The maximum annual capacity of the DCT is 600.000 TEUs (since 2007), however according to plans, the complete development will have an annual capacity of 4.000.000 TEUs (DCT, 2010).

At present the majority of freight is carried by road, although in Poland it is one of the most underdeveloped subsystems of the economy and the progress in construction of new sections is far from satisfying in comparison to growth of traffic (Burnewicz, 2010). The main road connection between the ports of Gdansk and Gdynia, and Bydgoszcz Inland Junction is the state road nr. 1. Part of this journey (approximately 100 km of 170 km total distance) may be covered via motorway A1 section linking Pruszcz Gdanski and Nowe Marzy. The 65 km section linking Nowe Marzy and Torun is planned to be finished by the end of 2011. The journey to Bydgoszcz Inland Junction, approximately 50 km, can be continued via state road nr. 80.

So far road pricing is introduced only on motorways. However, the new project of National Spatial Management Concept (2011) recommends introduction of road pricing on express roads. The railway route from Gdynia to Bydgoszcz includes parts of two lines - E 65 (from Gdynia to Tczew) and CE 65 (from Tczew to Bydgoszcz). Both of those lines are part of pan-European transport corridor linking the Baltic region with the areas bordering the Adriatic Sea and the Balkans. Within the Polish Corridor VI those lines connect Gdynia and Gdansk - via Warsaw or Katowice - with the southern boundary of the country. At present, works are carried out on both sections parallel to analyzed part of IWW E 70: Gdynia – Tczew and Tczew – Bydgoszcz. One of the main aims of the project is to increase freight train velocity up to 120 km/h and the maximum axle weight to 22.5 t., so that the railway would increase its competitiveness to the road transport system.

The IWW E 70 connects Rotterdam, through the Berlin junction of inland waterways and northern regions of Poland, with the region of Kaliningrad and the system of the Niemen (Pregola) and Dejma to Klaipeda. The Polish section runs along the Warta and Notec Rivers, through Bydgoszcz Canal and the Brda, and then it joins the Vistula (and the IWW E 40) in the Bydgoszcz Inland Junction. Then the route follows a section on the Vistula, Nogat Rivers and the Vistula Lagoon to the Polish-Russian border.

The E 70 and E 40 waterways along the Bydgoszcz-Gdansk link the multimodal north-south transport corridor with the multimodal west-east corridor. To become a part of European inland waterway system, the Polish parts of IWW E 70 as well as part of E 40 on the Lower Vistula have to upgrade from class II and I to class IV. This would enable safe navigation of vessels with a capacity up to 1.500 t during about 300 days a year. In 2007, the representatives of six regions located along Polish part of IWW E 70 declared their will of cooperation on this improvement. The result of this cooperation is a study inventorying the list of investments which are necessary to reach the level of class IV. However, the expected time of starting the project and the sources of funding are still not clear.

3.2. Methodology

Currently the transport model and system of data collection do not allow applying the same methodology as in the Antwerp case. In view of earlier decisions concerning rail and road investments, in the case of Gdansk and Gdynia, the most important question is the desirability of adapting the existing waterway for freight. The most important advantage in favour the development of inland waterway transportation may be cost savings. Taking into account only the energy consumption, the cheapest branch of freight transport is water transport. In the INERSEA Final Rapport (2010) it is concluded that the distance covered with the same amount of fuel and with the same load is 3.7 to 5 times larger for barges and freight ships than for lorries.

According to the Freight Modal Choice Study (2010) and the INTERSEA Final Rapport (2010), not only the economic cost should be taken into account. Very important are external costs which could be divided into four groups (Kulczyk & Winter 2003):

– Environmental costs (air and water pollution, noise, climate changes),
– Congestion costs (time and money loss, recycling costs, degradation of architectural and historical heritage),
– Infrastructure usage and maintenance costs,
– Accident costs.

Studies conducted in Germany in 2003 are showing that in road transport, external costs are almost 50% of the total costs. In rail and water transport, they are responsible only for 10-15% of the total costs. The most money-consuming are activities in the field of air protection and climate change (48% of the external costs) and accident recovery (29%). On the basis of the same study the relation of the total costs between road, rail and freight water transport is like 5 : 3.5 : 1 (Taczos *et al.* 2001).

Based on the German calculations, two scenarios were constructed for the future freight transport situation in the north of Poland. The first of them is referred to the situation without the usage of the IWW E 70 and the second involves the freight water transport on it showing the situation after revitalization of the inland waterway. It was assumed that the total costs, including external costs, will be analyzed and the relation between costs of the different transport modes will be fixed. In the studied scenarios, combined transport possibilities (road + rail transport, road + water transport, rail + water transport) were taken into account. The reloading points were localized in the nine main freight train centres in the region and in the five freight river ports situated on the analyzed part of the IWW E 70: Gdansk, Tczew, Kwidzyn, Grudziadz and Bydgoszcz.

3.3. Freight model and simulation results

In both scenarios two different freight transport possibilities were compared:

– Cost of road transport to / from Gdansk / Gdynia ports;
– Cost of road transport to / from rail freight centres and the costs of rail transport to / from Gdansk / Gdynia ports.
– In the scenario with the use of the IWW E 70, a third freight transport possibility was added: Cost of road and rail transport to / from freight river ports and the cost of water transport to / from Gdansk / Gdynia.

As a result, the transport costs were minimised. They were linked to the road and rail network in the north of Poland and illustrated using ArcGIS software. The results are presented in Figure 4.

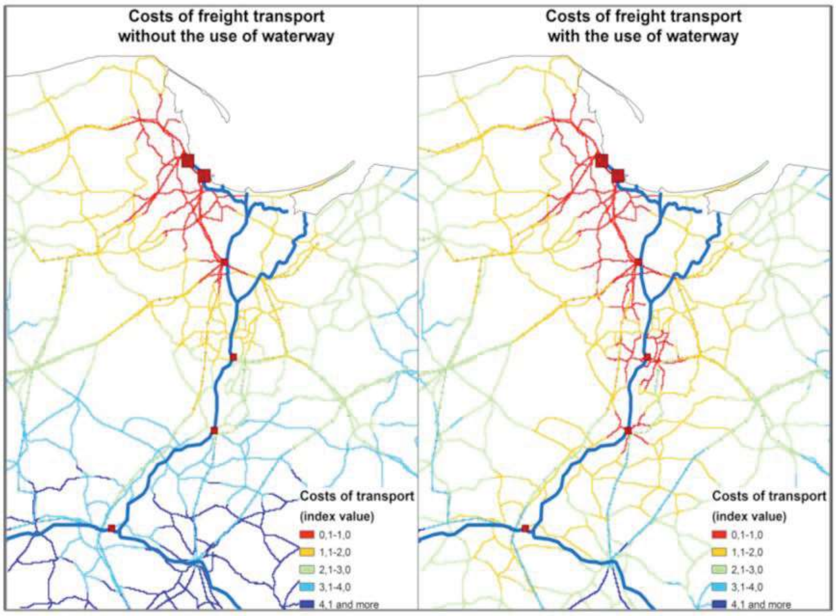

Figure 4 Gdansk-Gdynia case – costs in analyzed scenarios

The second output of the Gdansk / Gdynia study is the comparison between analyzed scenarios. The percentage differences between freight transport costs, in particular parts of the transportation network, are showing the possible cost savings after the waterway revitalization. The possible decrease in freight transportation cost is presented in Figure 5.

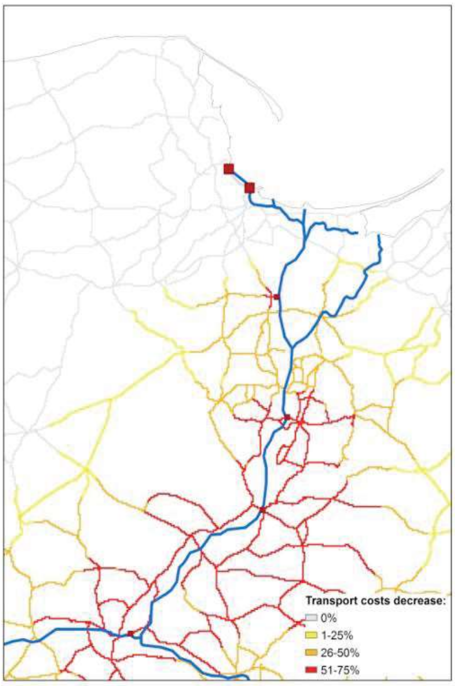

Figure 5 Gdansk / Gdynia case – scenarios comparison

4. Conclusions

There are many spatial analogies between the Antwerp and the Gdansk/Gdynia case. The most significant are the existence of an important port centre, comparable analyzed distance to the hinterland, as well as the existence of three possible means of freight transport. In the case of Gdansk and Gdynia however, waterways remain unused. Adaptation of the existing river system to the standards of IWW will require investments in its channel as well as infrastructure on land – e.g. ports, warehouses, links with local and the super-local transport network. Implementation of such a complex project should involve the state authorities as well as the local governments of the regions linked with the IWW E 70. In Poland, the cost of revitalization of the waterway appears to be the most serious obstacle delaying the decision to launch the project. In Belgium, improving the role of water transport is one of the transport policies that have political support of the government.

In both cases, different methodologies were used - appropriate to the available data and models. This comparative study shows the results obtained in similar spatial conditions. In both cases, improving conditions of water freight transport allow reducing internal and external costs. In the light of EU policy and the need of CO_2 reductions in transport, the perspectives of the development of water transport in both countries are promising. Road transport volumes in a huge part of the analysed regions could also be reduced as the result of multi-modal transport development. However, the used models of analysis differ. Existing freight transport model for Flanders is an advanced tool which allows analysing in detail the current transport situation and building future scenarios. The schedules of development of the road system in Poland as well as the road pricing policy are very vague. Therefore it is impossible to propose reliable detailed scenarios for the future. Nevertheless, even the simplified model, which does not consider potential new pricing mechanisms for road transport, proves that inland waterway freight transport can be highly competitive with road and railway transport. This is true not only in terms of international transport, but also on interregional scale, which is an important reference for decisions of national and regional authorities.

Due to expected growth of turnover in the ports of Gdansk and Gdynia, an introduction of IWW as an alternative for interregional transport appears to be the necessary. As the IWW E 70 will be upgraded, the Belgian experience and the used methodology can become a tool for Polish authorities to find the best solution for optimizing the performance of the new multimodal freight system.

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