Transport and Welfare Consequences of Infrastructure Investment: A Case Study for the Betuweroute

Mark J. Koetse[a,*], Jan Rouwendal[a,b]

[a] *VU University, Department of Spatial Economics, Amsterdam, The Netherlands*
[b] *Tinbergen Institute, Amsterdam, The Netherlands*

Abstract
This paper presents a study on appraisal of the Betuweroute, a 160 kilometre dedicated freight railway line connecting the port of Rotterdam with the German Ruhr area. The Betuweroute is an interesting example of a major investment in railroads for several reasons. Political decision making on the Betuwe project and calculations on its profitability were based on questionable assumptions, the two most important ones being that freight transport by trucks would become substantially more expensive, and that inland waterways would not be used more intensively for freight transport. Even though construction is completed, it is still unclear to what extent the route is going to be used in the future. Even though this may suggest that the Betuweroute is financially unviable, it should be noted that it provides a potentially important link in the transport network that links the major harbours of Hamburg, Rotterdam and Antwerp with the German hinterland. If the line could – in the near or more remote future – attract a large share of transit freight, as was expected in official project appraisals, it will be of considerable importance for the competitive position of the port of Rotterdam relative to Hamburg and Antwerp. In the paper we provide a brief review of the history of the project and its place in the freight transport network of north-western Europe. Then we proceed to a formal analysis of the impact of pricing of the various modes on the appraisal of the Betuweroute, based on the MOLINO model. The network we use includes the ports of Rotterdam, Antwerp and Hamburg and distinguishes between transport by road, railway and inland waterways. Since the Betuweroute connects Rotterdam to the Ruhr area, we use transport to and from this area as the driving force of the transport flows on this network. We present model simulations for scenario's with and without the Betuweroute and with and without marginal social costs pricing.

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[*] Corresponding author: VU University, Department of Spatial Economics, De Boelelaan 1105, 1081 HV, Amsterdam, The Netherlands. Tel: + 31 (0)20 598 6168, Fax: + 31 (0)20 598 6004, E-mail: mkoetse@feweb.vu.nl.

1. Introduction

This paper presents a case study on the Betuweroute, a 160 kilometre dedicated freight railway line connecting the port of Rotterdam with the German hinterland. This project is one of the European TEN-T projects which secures a financial contribution from the EU. The case study is interesting given its political background and its international scope. Political decision making on the Betuwe project and calculations on its profitability were based on questionable assumptions, making a comparison with results presented in this paper all the more interesting. However, if the railway line indeed attracts a large share of transit freight, as expected in official project appraisals, it may considerably improve the competitive position of the port of Rotterdam. This may have substantial consequences for other ports, such as Antwerp and Hamburg, but also for the competitive position of other transport modes, such as road and inland waterway transport.

The construction of this dedicated freight railway line across the Netherlands was motivated by two main reasons (TCI, 2004 and Algemene Rekenkamer, 2000):

- Economic reasons: to consolidate the (economic) position of the port of Rotterdam as one of Europe's key transport and distribution hubs (employment) and facilitate the expected growth in freight traffic in the Netherlands;
- Environmental reasons: rail was considered as a relatively environmental friendly mode of transport and the Betuweroute was expected to be a realistic substitute for road transport.

The scope of the Betuweroute project is not limited to the Netherlands. Most of the freight transported over the rail infrastructure will be transit, i.e., origin and destination of the goods are outside the Netherlands. As a consequence it is not only be the Dutch economy that may benefit from the new connection, also many other European countries may gain from an improved service (e.g., in terms of travel times and reliability). This has motivated the European Commission to include the Betuweroute (or Betuweline as named by the EU) as a priority axis (number 5) into the Trans-European transport networks, which implies additional funding from the Commission for the Betuwe project. According to the EU the line will improve freight links between the Netherlands and the rest of Europe, boosting Rotterdam's development as a major centre for transport, distribution and production (EC, 2005). The dedicated freight railway line is also expected to deliver benefits to road users and to the environment (by moving freight off the road). The project therefore clearly has an European scope.

This paper was written as part of the FUNDING project, which aims to develop a scientifically sound approach to assess the impact of different transport pricing regimes on the appraisal of large transport infrastructure investments in the EU. In this project the MOLINO II model is used to analyse the effects of the developed funding scenarios in terms of financial structure, timing of investment decisions, pricing decisions and welfare for a number of different case studies with a uniform methodology. The model is calibrated on the basis of recent transport demand flows. It represents transport flows, pricing, financing and investment decisions related to the project itself. We will model a relevant network situation and assess the consequences of the new railway infrastructure, i.e., the Betuweroute.

The remainder of this paper is organised as follows. Sections 2 and 3 explain the Betuweroute project and its current status from an international and national perspective, respectively. Specific attention will be paid to the political decision-making process. Section 4 discusses earlier assessments of the Betuweroute. In Section 5 we present the model we use for our analyses and Section 6 discusses the modelling scenarios and the inputs of the model. Section 7 analyses the model outcomes. Section 8 concludes.

2. The Betuweroute: The international setting

Even though the local and regional consequences (e.g., increased employment in Rotterdam and the deterioration of the landscape in the Betuwe), have attracted much attention in the national discussion on the desirability of the Betuweroute, its real significance only becomes clear when it is placed in the international context. The port of Rotterdam – until recently the world's largest harbour - is operating in an increasingly competitive market. In the past, ports were fairly insulated from competitive forces. Each port served its own, more or less captive, hinterland (Haralambides, 2002). Trade barriers, national borders and inadequate hinterland infrastructure were mainly responsible for this situation. The 'natural' hinterland of the port of Rotterdam was determined by the river Rhine, with the Ruhr area as its core. Important trade barriers associated with national boundaries were removed in the 19th century and inland waterway transport was the dominant mode until the 1950s. Since then the situation has changed considerably. The increasing importance of road transport challenged the traditional determination of port hinterlands. The connection between Rotterdam and the Ruhr area by inland waterways is much better than that of Antwerp or Hamburg, but the differences in accessibility by road transport are less substantial. Due to a growing internationalisation of production there has been a shift in manufacturing activities towards countries with a comparative advantage, thereby increasing the volume of transport flows. Moreover, containerisation and the development of multimodal transport have had a profound impact on port structures. European ports are facing major external challenges, including the grouping of container shipping lines into powerful consortia (resulting in downward pressure on prices), increased efficiency levels in maritime transport and the importance of logistical chains (Farrell, 1999). These developments, in combination with trade liberalisation (associated with the emergence of a single internal EU market) and technological changes (application of information technology in communication, standardisation of load units), has had a considerable impact on trade flows and hence on the port industry. The result was a more competitive market situation in which hinterlands are no longer captives of the port with which they have the best connection. The mobility of the transhipment container, together with intertwined land transport networks have simultaneously extended the hinterlands of all ports and intensified competition among these ports (Haralambides, 2002). Today, it makes little difference if a container from Asia destined for Duisburg will pass through the port of Hamburg, Rotterdam or Antwerp.

Competition concentrates on the extensive port-based logistic chains that developed in close relationship with the containerisation (Meersman et al., 2002). It is important for ports to belong to a successful logistic chain of a particular freight flow and for this purpose efficiency and other characteristics of the ports themselves are important, but also the connections with the hinterland. An adequate transport infrastructure, which should not be limited to a single mode, is an important element in any attempt to retain or increase market share.

The Betuweroute is such a potentially important transport axis connecting the port of Rotterdam with its German hinterland. It offers an alternative to road transport that may be of considerable importance in view of the continuing problems of traffic congestion and negative environmental externalities associated with truck transport. A fast connection by rail of a high quality may give the Rotterdam harbour an important competitive advantage to other ports in the Hamburg-Le Havre range. It becomes relatively more attractive for freight forwarders and transporters to make use of the port of Rotterdam when, for instance, freight goes from Eastern Europe to New York. Moreover, the presence of this route implies that a high quality alternative for road transport is present when congestion problems or taxes associated with environmental damage would make road transport less attractive.

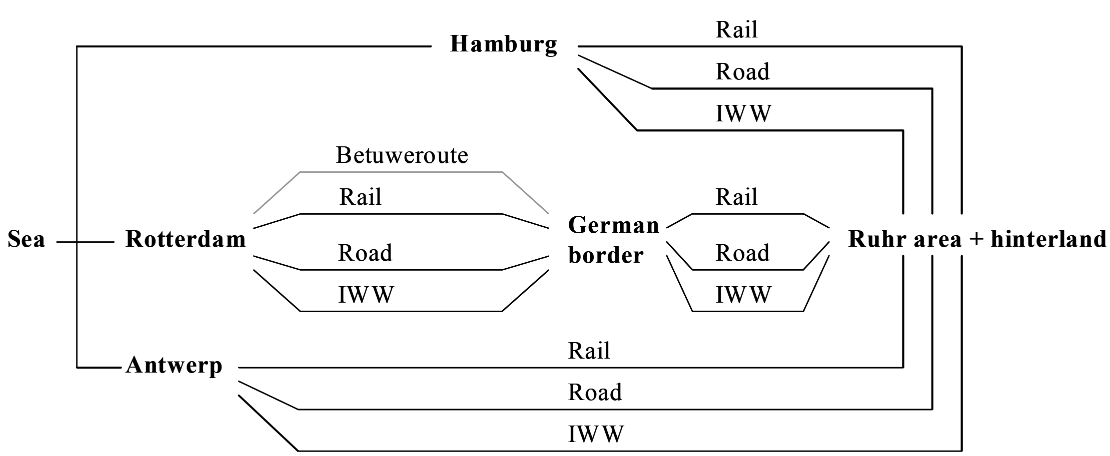

Figure 1: The infrastructure network analysed in our case study (IWW is inland waterways)

The infrastructure network we use in the modelling exercise reported below reflects some important aspects of this international context. It is shown in Figure 1 and focuses on the position of the Betuweroute in the competition between Rotterdam, Antwerp and Hamburg for international freight transport. We concentrate attention on freight that arrives from over the North Sea and moves to the hinterland of the Rotterdam harbour beyond the German border, in which the Ruhr area still occupies a central position. This international freight may use the ports of Rotterdam, Hamburg or Antwerp and from there use (existing) rail, road or inland waterways. The Betuweroute implies a substantial improvement in the available rail infrastructure and for this reason we model it as a separate mode. A special characteristic of the Betuweroute is, of course, that it is only available until the German border, which is therefore included as a separate 'node' in the part of the network that connects Rotterdam with its hinterland. We realize, of course, that the network outlined in Figure 2 is actually not only used by international freight transport, but also by other types of travel and that there exits important interactions between the various user groups. In section … we will discuss how we dealt with these issues.

It will be clear from the discussion above that the scope of the Betuweroute, is not limited to the Netherlands. Most of the freight transported over the rail infrastructure will be transit, i.e., origin and destination of the goods are outside the Netherlands. As a consequence it is not only be the Dutch economy that may benefit from the new connection, also many other European countries may gain from an improved service (e.g., in terms of travel times and reliability). This has motivated the European Commission to include the Betuweroute (or Betuweline as named by the EU) as a priority axis (number 5) into the Trans-European transport Networks (TENs), which implies additional funding from the Commission for the Betuwe project. According to the EU the line will improve freight links between the Netherlands and the rest of Europe, boosting Rotterdam's development as a major centre for transport, distribution and production (EC, 2005). The dedicated freight railway line is also expected to deliver benefits to road users and to the environment (by moving freight off the road). The project therefore clearly has an European scope.

3. The Betuweroute: The national debate

Port authorities and firms located in the Rotterdam harbour were, of course, keenly aware of the changing international context in which they had to operate. Moreover, throughout the 1970s there had been an increasing awareness of environmental problems associated with transport in general and growing concern about the desirability of continued economic growth. In the early 1980s Europe suffered from the worldwide recession associated with the second oil crisis. In this situation a new awareness of the vital importance of the market economy for the sustainability of the welfare state emerged, while at the same the awareness grew that economic growth and measures to avoid or appropriately mitigate environmental damage might coincide. The first development resulted in an emerging consensus among Dutch policy makers about the so-called 'mainport' concept. Mainports were regarded as the engines of economic growth and Schiphol airport and the Rotterdam harbour were considered as the most important examples in the Netherlands. High quality infrastructure was regarded as a major condition for the continuation of their mainport position. The second development gave rise to the idea that substantial freight transport was unavoidable in modern economies and that it would therefore be best to concentrate attention on minimizing the associated environmental damage. The general idea was that rail transport was more environment friendly than road transport. In this context the first plan for the Betuweroute emerged.[1]

The original idea for a Betuweroute concerned the upgrading of the existing (single track) railway to accommodate a substantial flow of freight transport.[2] In Rotterdam it was realized that plans for increasing freight transport by rail could benefit from the existing environmental concerns as well as from the growing enthusiasm for mainport development. The latter was fuelled by the development of the association Nederland DistributieLand (NDL) (=Netherlands Logistics Country) which lobbied for this idea. In 1989 the Dutch minister of transport installed a commission to investigate the possibilities for freight transport by rail. This commission developed the idea of a new railway dedicated to freight transport across the Betuwe. The main argument in favour of this new plan was the (unsubstantiated) claim that Rotterdam would miss large amounts of incomes and investments unless a major improvement in rail infrastructure would be realized. This plan fitted well in the desire to position the Netherlands the 'Gateway to Europe' propagated by NDL. The Betuweroute was immediately incorporated in the investment plan of Dutch Railways (NS), which needed approval by the government. Even though the Dutch ministry of transport initially had substantial reservations with respect to a dedicated freight transport route, effective lobbying resulted in the incorporation of the plan in the white paper Structuurschema Verkeer en Vervoer II (SVV2) (=Second Structural Scheme Traffic and Transport). Reduction of CO_2 pollution associated with road transport and accessibility of the Rotterdam mainport were the main arguments for this decision.

After being developed further, the Betuweroute project comprised an upgrade of the existing Rotterdam Port Railway, which runs from the Europoort at Maasvlakte via the Waalhaven container rail service centre to the Kijfhoek shunting yard, and constructing a new double-track line that parallels the A15 motorway to the German border near Emmerich. It links the port of Rotterdam to the existing German rail network at the Dutch/German border.

The government decision to build the Betuweroute was taken in 1994 and was ratified by a committee and parliament in 1995. Work to upgrade the port railway started in 1997. Construction of embankments, tunnels and bridges for the A15 line began in 1998. The Betuweroute is the first double-track railway line in the Netherlands dedicated to freight transport. It was completed in July 2007.

Total costs amount about 4.7 billion Euro according to recent estimates, with a 135 million Euro contribution by the EU (EC, 2005). The 25-tonne axle load Betuweroute will have a capacity of 10 trains per hour in each direction. Top speed will be 120 km/h and trains are expected to take between one-and-a-half and two hours to travel the 160 kilometres from Europoort to the German border.

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[1] See Pestman (2001, chapter 4) for a more elaborate discussion.

[2] Poeth and Van Dongen (1983)

4. Earlier assessments of the Betuweroute

The completion of the Betuweroute ends a period of about 25 years of planning, research, construction and last, but certainly not least, discussion. The railway line has been very controversial for many reasons. The analyses of social costs and benefits of the route to be discussed in the present section sometimes played a major role in the decision making process.

We noted above that The Dutch government introduced the new railway hinterland connection between the port of Rotterdam and Germany in a policy document in 1990 (Second Structural Scheme for Traffic and Transport). The project is launched there as a possibility to deal with the expected growth in freight transport, but the details of the project are to be filled and careful comparisons with other alternatives have not yet been made. However, at that time the Betuweroute is already a serious option to policy makers.[3]

Dutch Railway commissioned an assessment of the Betuweroute by the Swiss consultancy company Knight Wendling. An early document, Knight Wendling (1991) provides the main conclusion:

> *Construction of the Betuwe railway route is (...) necessary to realize the targets of government policy with respect to freight transport as formulated in the Second Structural Scheme Traffic and Transport. The necessity of construction is endorsed by economic and social issues like environmental concern, infrastructure capacity and economic cost/benefit ratio. Also from an international perspective the Betuwe freight railway route is an indispensable link to execute EU-policy and to react appropriately to the changing position of road traffic.* (Knight Wendling, 1991, p26)

In the next year this conclusion was documented by a 'macro-economic and social cost-benefit analysis of the Betuwe route' (Knight Wendling, 1992) that stated that until 2010 tax revenues with a present value of 11.9 billion Dutch guilders (5.40 billion Euro) would be forgone if the Betuwe route would not be constructed. Improvement of inland waterway transport could limit this loss to 7.6 billion Dutch guilders (3.45 billion Euro). The costs of the Betuweroute were estimated to amount to 5.2 billion Dutch guilders (2.36 billion Euro) and it was expected that this investment would be paid back completely by 2000.

The Knight Wendling conclusion is remarkable for a number of reasons. In the first place, Knight Wendling was asked by Dutch Railways (NS) to compare two alternatives: a reference case in which freight transport by rail would completely disappear, and one in which freight transport would grow to 65 million ton per year. The latter figure was based on a target set by NS, which is generally considered as ambitious. This implies that Knight

[3] Indeed, it appears that many members of parliament interpreted the incorporation of the Betuweroute in the Second Structural Scheme for Traffic and Transport after this had passed parliament as a decision to construct the railway. This explains why later discussion in parliament tended to concentrate on implementation issues.

Wendling did not itself assess the effect of construction of the Betuweroute on freight transport. In other words, the direct effect of the Betuwe route on the development of the volume of freight transport was taken as given (that is, incorporated in the self-imposed target set by NS) rather than estimated.

The reference scenario in which freight transport by rail disappears was probably not unreasonable since this transport mode had been losing market share for years. At the time, NS apparently regarded the construction of the Betuwe route as the last possibility to revive this part of its activities.

The reasoning in the Knight Wendling report is macro economic and stresses the indirect or secondary effects. Later on it became clear that a substantial part of the effects reported by Knight Wendling were ‘image’ effects for the Rotterdam harbour that are absent in conventional economic models like those used by the CPB. This illustrates the heavy weight attached to the mainport argument.

The large macro-economic benefits suggest that it is unnecessary to care much about the returns to the investment in terms of user fees. The capital invested in the Betuwe route would soon be paid back by (other) tax revenues, at least if the optimistic assumptions about the development of freight transport were accepted. A later analysis by the CPB concluded that even after subtraction of the ‘image’ effects the Betuwe route still appeared to be a worthwhile investment.

The CPB was, however, quite critical about the possibilities to realize the self-imposed target set by NS. Nevertheless, it did not provide an independent assessment of the development of freight transport in general, let alone of the demand for transport over the Betuwe route. As a matter of fact, such an independent assessment was never commissioned by the politicians who had to take the decisions. McKinsey was asked to assess the realism of the modal share of rail and concluded on the basis of a ‘best practice’ studied that used information about Sweden and the US that this share could be reached under particular conditions. However, there was never a study that investigated the demand for freight transport over the Betuwe route under particular conditions of price and quality.

The Knight-Wendling report states that with this the strong growth of freight transport by rail included in the self-imposed target of NS, existing capacity will be insufficient. This last step towards the conclusion that the Betuwe route should be constructed in the interest of national welfare appears reasonable since the existing railroad network in the Netherlands is used intensively for passenger transport. However, a later CPB study stated that doubling the existing railway between Rotterdam and Utrecht served to postpone any capacity problems for freight transport to (at least) 2010 and suggested phased decision making. Recent CBS figures indicate that about 29 mln tonnes of freight were transported by rail in 2005 in the Netherlands (CBS, 2006) and there are no serious indications of capacity problems even though the Rotterdam-Utrecht railroad has not been doubled and the Betuwe route was not yet available.[4] Moreover, there appears to be no interest at all in freight transport over the Betuwe route immediately after its completion in July 2007. We conclude therefore that even this seemingly trivial step in the argument was less innocent than it seems to be at first sight.

Finally, it is surprising that the Knight Wendling report almost completely ignores the – supposedly beneficial – environmental effects of the Betuwe route, which were a second main argument in favour of its construction. It appears that this argument was more or less taken for granted by many in the beginning of the 1990s on the basis of a comparison with passenger transport, for which there is a clear difference between the two modes. However, a 1994 study by the RIVM compared the environmental effects of transporting an equal amount of freight by road and rail, and found relatively modest differences. Moreover, it was soon criticized for ignoring new developments in truck technology that mitigate the environmental damage caused by trucks. It was also pointed out that the Betuweroute was expected to generate a substantial amount of additional freight, which increased pollution et cetera. The conclusion emerged that the environmental effects of the Betuweroute could safely be ignored.

The 1994 election lead to a change in government. Two parties that had expressed important reservations with respect to the desirability of the Betuwe route participated in the new coalition, and a committee was installed to reconsider its effects in preparation of a final decision. This committee-Hermans, as it was called after its chairman, produced a lengthy report in which the Betuweroute was explicitly placed into the international context. The mainport argument therefore still figures prominently. The committee expressed scepticism about cost benefit analyses in general: in the context of sustained economic growth every investment in infrastructure would pass the test if the time horizon was put sufficiently far from the present. This somewhat surprising point of view seems to suggest that the committee expected prolonged growth of traffic at an annual rate close to or even above 4% per year, the rate of discount used in official cost-benefit analyses at the time. Given this optimism, it comes as a second surprise that the committee was even more sceptical of the possibilities to recover the costs associated with infrastructure investments: only under stringent conditions could exploitation costs perhaps be recovered, but not the capital invested in the route.[5]

The report made it explicit that the Betuwe route was especially important as a (potential) alternative for road transport, which was expected to become much more expensive because of taxes and constraints associated with the environmental damage it caused. Indeed, the committee stated that higher costs of road transport were a necessary conditions for taking a positive decision about the Betuwe route. Inland waterways were not considered to be able to provide a viable alternative to road transport, since only a limited number of destinations could be reached by that mode. At the time the decision about construction of the Betuweroute was taken such an increase in the price of road transport was

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[4] In the Knight-Wendling scenario total freight transport by rail would be equal to 30 million ton by 2000.

[5] The earlier government has stressed the importance of the participation of private parties in the project. Indeed, minister Maij of transport regarded this as an essential condition for starting construction of the Betuweroute.

not intended by then current transportation policy, and the white paper that followed (Transport in Balans) did not propose it.

The report of the committee-Hermans played a major role in the final decision about the construction of the project, which was taken in 1995.

5. The transport model

The model used for our analysis is the MOLINO model developed at the Katholieke Universiteit Leuven. The model structure allows for an economic assessment of improvements in a transport network with various nodes, links and paths. A full description of the model is outside the scope of this paper, and we restrict the discussion that follows to highlighting the features that are crucial for understanding and interpreting the results presented in the sections that follow.

The actors in the MOLINO framework are users of the transport network. They are assumed to have a common structure of their utility of production functions, which can be described by a decision tree. Since international freight transport occupies a central position in our analysis, we start with the demanders of this transport who are located in the German hinterland. Their production function has – at the highest level - two arguments: domestic goods and international transport. The latter should be interpreted as a composite commodity, whose value is determined by the various transport types. The idea is that any level of production can be realised with various combinations of transport and other inputs and that the actual amount of transport used will depend on its relative price.

The composite commodity 'transport' is determined by peak and off-peak transport by means of a lower-level production function. At a still lower level, the amounts of peak and off-peak transport are determined by the links of the network used. For international transport, these links are determined by the port used (Hamburg, Rotterdam of Antwerp) and the transport mode (road, rail or inland waterway). We treat the Betuweroute as a separate mode, that is only relevant for transport that passes through the Rotterdam harbour.

This structure of the production function is illustrated in Figure 2. For simplicity we have assumed in that figure that only two links have to be distinguished, whereas in reality there are 9 or 10 (depending on the inclusion of the Betuweroute in the set of links). For each level of the production structure a CES-function is assumed to be relevant. Such a function is characterized by a constant elasticity of substitution (hence the name). For two inputs, the CES function looks as:

$$x = \left(a\, y_1^{\sigma} + b\, y_2^{\sigma}\right)^{1/\sigma}, \qquad (1)$$

where x denotes the amount of output, y_i the amount of input i, a and b are scale coefficients, and σ is the crucial parameter of this function because it determines the elasticity of substitution between the two inputs as well as the price elasticities of their demand.

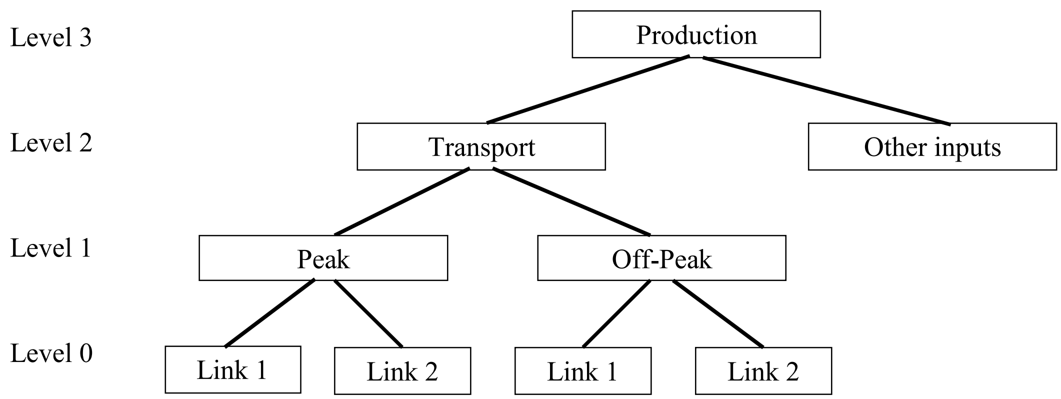

Figure 2. Example of the production function with two links

The nesting structure shown in Figure 2 can be thought of as a decision tree. A producer who wants to make a certain number of units of the final product first decides how many units of transport and other inputs to use. In the next step, he decides how this total amount of transport is determined by peak and off-peak transport. Then he decides how the required amount of peak transport is determined by goods shipped by rail, road or inland waterway from Hamburg, Rotterdam or Antwerp.

Even though the analysis of this paper concentrates on the Betuweroute and international freight transport, we have to take into account that the network sketched in Figure 1 is also used for other purposes and that the various user groups interact with each other. For this reason we have also introduced a number of other actors into the model.

First of all, we want to take into account that the network is not only used for international freight transport, but also for transport of domestically produced goods. These are transport flows that originate from one of the three ports, Hamburg, Rotterdam and Antwerp and have the German hinterland as their destination. We include them into our model by introducing three additional actors that produce by domestic transport from one of the three ports and other inputs. The production structure of these actors is almost the same as that of the international freight transporters: the only difference is that the number of links is restricted to 3 or 4 (in case of Rotterdam with the Betuweroute as one link).

Second, we have to take into account that part of the network is also used for passenger transport. The generation of this type of transport is modeled by means of a utility function that is also of a nested CES type. The nesting structure is analogous to that for the producers, taking into account that inland waterways are not used for passenger transport. We abstract from international passenger transport and introduce four actors generating transport. The origin-destination combinations of these four actors are: Hamburg – German hinterland, Antwerp – German hinterland, Rotterdam – German border and German border – Hinterland.

The various actors in the model interact with each other if they use the same network link. This interaction is modeled through a travel time function, which gives the travel time on a particular network link as a function of the total flow of transport of the network. Travel time (*tt*) on a certain link is given by the following speed-flow relation:

$$tt = \frac{l}{v}\left(1 + \alpha\left(\sum_j pce_j \times q_j \Big/ c\right)^{\beta}\right), \qquad (2)$$

where l is length of the link, v is maximum free-flow speed, pce_j is passenger car equivalent for vehicle type j, q_j is the number of vehicles per hour of type j, c is free-flow capacity, and α and β are (exogenous) congestion function parameters. In this equation the total transport flow is defined as the weighted sum of the number of vehicles, where the weight is the number of passenger car equivalents. For instance, for road transport a truck is typically counted as equivalent to three passenger cars, implying that pce_j=3 for j equal to trucks.

The travel time function in equation (2) was originally developed for road transport and is sometimes referred to as the Bureau of Public Roads (BPR) travel time function. In our model it is also use for rail transport and inland waterway transport. *Travel time cost* is equal to travel time as given by equation (2), multiplied by the value of time. The generalised prices used at each level are the sum of unit resource costs, costs of travel time, i.e., including internal time costs of congestion, and tolls (if present).

The calibration of the model starts by choosing reasonable values for the elasticities of substitution σ for all levels of the production or utility functions of all actors. For the given values of generalized travel costs, optimizing behavior then generates the transport flows as functions of these elasticities of substitution and the scale parameters of the utility and production functions, which have been denoted as *a* and *b* in equation (1). These parameters are determined exactly by the values of the transport flows in the initial situation and arbitrarily chosen constants for the ‘other inputs’ in level 2 in Figure 1.[6]

6. Modelling scenarios and inputs of the model

Our network analysis focuses on the implications of the Betuweroute on port competition. Using the network in Figure 1, but without the Betuweroute, as our baseline network, and current pricing as our baseline pricing scheme, our modelling analysis first considers the implications of the new Betuweroute infrastructure. Second, it investigates the impact of an alternative pricing scheme, i.e., marginal social cost pricing plus a mark-up for costs of infrastructure maintenance and operation. This results in 4 four different scenarios that are summarised below:

[6] These values may be set equal to 1.

- Scenario 1 (baseline scenario): Current pricing, without Betuweroute;
- Scenario 2: Marginal social cost pricing plus mark-up for costs of infrastructure maintenance and operation, without Betuweroute;
- Scenario 3: Current pricing, with Betuweroute;
- Scenario 4: Marginal social cost pricing plus mark-up for costs of infrastructure maintenance and operation, with Betuweroute;

Under marginal social cost pricing the external costs of congestion, greenhouse gas emissions, local pollution, noise and accidents, are incorporated in the generalised prices. Costs of infrastructure maintenance are not included.

Important to note is that in our model the central government is the owner, manager and operator of all links, except the Betuweroute. The Betuweroute is operated and managed by a single separate entity. Therefore, except for the Betuweroute, all issues related to differences between private and public ownership, and between differences in organisational structures, are left out of the equation.

Regarding inputs of the model, data passenger and freight flows for specific routes are generally not available. This means that many assumptions are necessary. Ultimately, local and specific route knowledge is needed in order to calibrate the existing flows on the network links. In order to get some idea on the distribution of freight and passenger transport demand over the different links we use the ETIS database. The ETIS database contains freight and passenger transport flows for origin-destination combination at the NUTS 2 level. Specifically, we derive the freight and passenger flows from NL33 (as a proxy for Rotterdam), BE21 (as a proxy for Antwerp) and DE6 (Hamburg) to three NUTS 2 regions that partly overlap the Ruhr area, DEA1, DEA3 and DEA5. Of course, total transport flows are larger than the resulting flows, but the latter at least give us an idea of the distribution of international flows over the three links.

To get an idea on absolute figures we use data on realised rail freight flows on the East-West axis from the CBS (Statistics Netherlands, http://statline.cbs.nl). This figure turns out to be a factor 24 higher than the figure drawn from the ETIS database. We therefore multiply all freight flows by rail by 24. Total domestic freight by rail in the Netherlands over the East-West axis is 0.28 times international freight. Domestic freight in The Netherlands is upgraded accordingly. Total international road freight transport from Germany to Netherlands and the other way around is 68 mln tonnes. This is approximately a factor 17 higher than flows obtained from the ETIS database. We adjust the figures accordingly. Since data for Germany and Belgium are not available, we apply the same scaling factor to road freight transport from Antwerp and Hamburg. Total water freight transport for freight loaded in Rotterdam with destination Germany, Austria or Switzerland, and the other way around, is around 90 mln tonnes. This is a factor 2.3 higher than in the ETIS database, which is used as a scaling factor for water transport. We make the simplifying assumption that purely domestic transport is zero, i.e., every tonne transported over Dutch waters is transported to Germany. Since data for Germany and Belgium are not available, we apply the same scaling factor to inland navigation transport from Antwerp and Hamburg. The different scaling factors for the different modes imply that the ratios between modes obtained from the ETIS database are lost. However, the ratios within modes, and between routes, remain intact. Absolute figures on passenger transport on specific routes is hard to come by. This is why we use the same scaling factors for passenger transport. Although this potentially erroneous assumption has no direct impact, it may influence the results through the congestion functions. Finally, in order to make a distinction between transport flows during peak hours and off-peak hours, we assume that 70% of freight transport and 80% of passenger transport takes place during peak hours, for all modes. The resulting passenger and freight transport flows on the links in our network are presented in Table 1.

Table 1. Initial quantities on the various paths in the network in 2000, excluding the Betuweroute

		Passenger		Local freight		Transit freight	
		Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Rotterdam-German Border	Road	95,000	41,000	124,000	53,000	-	-
	IWW	-	-	-	-	-	-
	Rail	28,000	12,000	2,000	500	-	-
Rotterdam-Ruhr	Road	48,000	20,000	124,000	53,000	17,000	4,000
	IWW	-	-	50,000	13,000	144,000	36,000
	Rail	14,000	6,000	7,000	1,800	28,000	7,000
Antwerp-Ruhr	Road	16,000	6,800	257,000	64,000	49,000	12,000
	IWW	-	-	51,000	13,000	11,000	2,800
	Rail	2,000	800	35,000	8,500	3,500	1,000
Hamburg-Ruhr	Road	82,000	35,000	55,000	14,000	37,000	9,500
	IWW	-	-	1,700	500	500	200
	Rail	64,000	27,000	94,000	23,000	52,000	13,000

With respect to the Betuweroute there are no appraisals that contain explicit freight flow predictions, so an assumption is necessary here. Assuming a capacity of 680 tonnes per train (see Table 3) and an estimated number of trains per year of 20,000 (personal communication with Keyrail, operator of the Betuweroute), we arrive at a freight flow on the Betuweroute of approximately 14 million tonnes in 2008. We set initial quantities on the Betuweroute in 2000 such that in 2008, in the scenarios with the Betuweroute and given the parameter values stated below, a freight flow of 14 million tonnes on the Betuweroute is obtained. The maximum speed on the Betuweroute is set at 1km/h per hour in 2000, effectively keeping the flows on the Betuweroute at zero. In the scenarios with the Betuweroute we increase the maximum speed to 100 km/h in 2008.[7] Other assumptions on the Betuweroute are that tolls are 0.33

[7] In order to calibrate the model using identical data in all scenarios we calibrate the model with a maximum speed on the Betuweroute of 1 km/h. In the scenario's with the Betuweroute we increase the speed to 100 km/h in 2008. We set quantities on the Betuweroute in 2000 such that in 2008, for the scenarios with the Betuweroute, a transport flow of 14 million tonnes is obtained. This flow is substituted to the Betuweroute from other links.

Euro per tonne per trip, capacity is 20 trains per hour (10 in each direction), operation and maintenance costs are 20% lower than those of existing rail infrastructure.[8] Finally, investment in the Betuweroute is estimated at 4.7 billion Euro (EC, 2005). Finally, transport flows have increased substantially in the past, so we implement a generic yearly growth rate of 2% (percentage change is measured over the yearly transport flow output of the model, not over the initial figures). Within the context of the model this implies that congestion becomes more and more important over the years.

Values of general, not link specific parameters are listed in Table 2. Some remarks are in order here. Parameters α and β are the congestion function parameters in equation (1), where α determines the impact of an increase in traffic flows on travel time, and β determines the curvature of this relationship. The latter parameter is set equal to one, which implies that the relationship is linear. The parameter α is chosen such that, for a trip of an hour and a flow-capacity ratio of 2, there is a delay of 24 minutes. Further, the passenger car equivalent (PCE) of a truck is set at 3 according to European standards, and transport share is set at 0.05, which means that 5% of all consumption is spent on transport.

Table 2. General (not link-specific) parameters

Parameter	Value
α	0.2
β	1.5
PCE truck	3
Transport Share	0.05
Elasticity periods passenger	0.2
Elasticity periods freight	0.2
Elasticity transport passenger	0.8
Elasticity transport freight	0.8
Elasticity paths passenger	1.5
Elasticity paths freight	1.5
Life Time infrastructure	35 years
Interest	4%

Important for the results of the model are the various substitution elasticities. Substitution elasticities between periods and between transport and other consumption are set equal to 0.2 and 0.8, respectively. The main consequence of this assumption is that time loss due to congestion leads to relatively small shifts from peak to off-peak transport flows, which of course also depends on the amount of congestion and the share of congestion costs in total resource costs. Substitution between paths for freight transport is assumed to be elastic; the

For the scenarios without the Betuweroute maximum speed simply remains at 1 km/h from year 1 to 25, which effectively keeps transport flows over the Betuweroute equal to zero.

[8] Keyrail expects that costs of maintenance and operation can be reduced by 20% (at a minimum) vis-à-vis costs of current practice in rail maintenance and operation (see www.keyrail.nl).

elasticity is set at 3. Finally, the life time of the Betuweroute is set at 35 years and the discount rate is equal to 4%.

Values for link-specific parameters and variables are summarised in Table 3. Note that most figures differ per mode but not per country and not per period. For example, road data for The Netherlands are transferred to Belgium and Germany. The reason is that we could not obtain specific data for Belgium and Germany. When figures differ per country this is because of differences in length of the various links. For example, fixed operation costs are based on operation costs per km infrastructure in The Netherlands. Because the links differ in length, operation costs also differ by link. The same holds for variable maintenance costs. Values for maximum speeds and number of peak hours per day are assumptions, while length of the various links are based on own calculations. Occupancy rates for road passenger transport are based on (informed) assumptions, while occupancy rates for rail passenger transport is based on information contained in NS and Prorail (2006). Data on occupancy rates for freight transport, measured in tonnes per vehicle, are from a detailed freight transport database in The Netherlands (see NEA et al., 2005). Resource costs for the three modes, consisting of depreciation costs, interest costs, insurance costs, labour costs and other direct transport related costs, are obtained from the same source. Further, free-flow infrastructure capacities for IWW and rail transport are based on own assumptions, while road infrastructure capacity is based on an assumption of 2 lanes per direction and 2,200 vehicles per lane per hour (see Smith et al., 1996). Values of time are important inputs for calculating costs of congestion. We use those that were used in the UNITE project (see Nellthorp et al., 2001). Finally, variable maintenance costs, fixed operation costs and external costs are derived from own calculations based on CE/VU (2004) and Statistics Netherlands (see http://statline.cbs.nl).

Of course, the results presented in the following section depend to a certain extent to the values for the parameters and variables discussed above. Especially important are the uncertainty around initial passenger and freight transport flows, the absolute and relative magnitudes of the various costs figures, and the assumption on the substitution elasticity between paths. Sensitivity analyses should provide insight into the sensitivity of the results to changes in these values.

Table 3. Link-specific inputs (units of measurement are given below the table)

Variable		**Rotterdam – German Border**				**German border – Ruhr**			**Antwerp – Ruhr**			**Hamburg – Ruhr**		
		Road	**Rail**	**IWW**	**Betuwe**	**Road**	**Rail**	**IWW**	**Road**	**Rail**	**IWW**	**Road**	**Rail**	**IWW**
Duration		8	12	8	12	8	12	8	8	12	8	8	12	8
Length		160	160	160	160	95	95	95	225	225	225	355	355	355
Capacity		8,800	20	12	20	8,800	20	12	8,800	20	12	8,800	20	12
Maximum Speed		68	60	8	100	68	60	8	68	60	8	68	60	8
Occupancy	Passenger peak	1.2	500	-	-	1.2	500	-	1.2	500	-	1.2	500	-
	Passenger off-peak	1	200	-	-	1	200	-	1	200	-	1	200	-
	Freight peak	15	680	1900	680	15	680	1900	15	680	1900	15	680	1900
	Freight off-peak	15	680	1900	680	15	680	1900	15	680	1900	15	680	1900
Resource costs	Passenger	0.54	12	-	12	0.89	12	-	0.89	12	-	0.89	12	-
	Freight	0.89	12	45.00	12	0.89	12	45.00	0.89	12	45.00	0.89	12	45
Variable MC	Passenger	0.51	386	-	-	0.3	230	-	0.71	543	-	1.12	857	-
	Freight	19.3	706	84	706	11.5	419	50	27.1	992	119	42.8	1565	187
Fixed OPC		7600	57000	41000	45,600	4500	34000	24000	10500	80000	57000	17000	125000	90000
VOT	Passenger peak	6.7	6.7	-	-	6.7	6.7	-	6.7	6.7	-	6.7	6.7	-
	Passenger off-peak	6.7	6.7	-	-	6.7	6.7	-	6.7	6.7	-	6.7	6.7	-
	Freight peak	2.9	0.76	0.18	0.76	2.9	0.76	0.18	2.9	0.76	0.18	2.9	0.76	0.18
	Freight off-peak	2.9	0.76	0.18	0.76	2.9	0.76	0.18	2.9	0.76	0.18	2.9	0.76	0.18
External Costs	Passenger peak	0.033	0.969	-	-	0.033	0.969	-	0.033	0.969	-	0.033	0.969	-
	Passenger off-peak	0.033	0.969	-	-	0.033	0.969	-	0.033	0.969	-	0.033	0.969	-
	Freight peak	0.175	1.381	1.204	1.381	0.175	1.381	1.204	0.175	1.381	1.204	0.175	1.381	1.204
	Freight off-peak	0.175	1.381	1.204	1.381	0.175	1.381	1.204	0.175	1.381	1.204	0.175	1.381	1.204

Variable	**Unit of measurement**
Duration	Number of peak hours per day
Length	Kilometres
Capacity	Free-flow capacity per hour
Maximum speed	Kilometres per hour
Occupancy	Passengers or tons per vehicle
Resource costs	Euro per vehicle kilometre
Variable maintenance costs	Euro per passenger or freight vehicle
Fixed operation costs	Euro per day
Value of time	Value of time per hour per passenger or tonne
External costs	Euro per vehicle kilometre (external costs of congestion, greenhouse gas emissions, local pollution, noise and accidents).

7. Simulation results

In this section we present the results from the model simulations for the four scenarios. In the following subsections we subsequently discuss the general welfare consequences and the consequences for transport flows on the network and the separate links.

7.1 Welfare consequences

In Table 4 we present an aggregate cost-benefit table. Note that tax rates are set equal to zero, so tax revenues do not exist and are not included in the table. The consequences of MSC pricing are according to expectation; passenger user surplus goes down because transport demand decreases, toll revenues increase for both the central government and the Betuwe operator, external costs drop substantially, and social welfare increases. Furthermore, construction of the Betuweroute induces a shift from road to rail transport (see next section), and total transport on the network increases slightly. The net effect is a slight increase in external costs. Ultimately, in accordance with earlier Betuweroute assessments, the construction and operation of the Betuweroute causes a drop in social welfare.

Table 4. Aggregate cost-benefit table for the four scenarios (figures are discounted sums in 2000)

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Passenger transport users' surplus (1)				
Total (x 10^6)	24,623	24,474	24,623	24,474
Freight transport users' costs (2)				
Local (x 10^6)	10,328	10,473	10,327	10,471
Transit (x 10^6)	3,413	3,455	3,409	3,451
Net user surplus (3) = (1) – (2)				
Total (x 10^6)	10,882	10,546	10,887	10,552
Toll revenues (4)				
Central government (x 10^6)	-	357	-	356
Betuwe	-	-	146,102	471,059
Infrastructure costs				
Investment Betuwe (5)	-	-	9,407,636	9,407,636
Salvage value Betuwe (6)	-	-	1,323,141	1,323,141
Operation and maintenance costs (7)				
Operation costs central (x 10^6)	65	55	65	55
Operation costs Betuwe	-	-	806,681	761,250
Profits operator (8) = (4) – (7) – (5) + (6)				
Central (x 10^6)	-65	302	-65	301
Betuwe	-	-	-8,745,074	-8,374,687
External costs (9)				
Total (x 10^6)	98	84	98	84
Total welfare (10) = (3) + (8) – (9)				
Total (x 10^6)	10,719	10,765	10,716	10,761

7.2 Changes in transport flows

Note that there is an autonomous growth in transport flows of 2% per year and that flows may furthermore change due to differences in congestion on the various links. This implies that total transport in 2025 can be maximally 64% percent higher than that in 2000 ($1.02^{25} = 1.64$), but that transport on a specific link may show a larger increase because of differences in congestion and associated substitution of flows between routes.

Scenario 1

In Table 5 we present indexed transport flows in the year 2025 for scenario 1, with initial transport flows in 2000 set at 100. Compared to 2000 the local and transit freight flows on the entire network in 2025 have grown by approximately 53% (not in table). Compared to a maximum growth of 64% we may therefore conclude that congestion substantially reduces freight transport flows. Furthermore, especially rail transport in the Netherlands and Belgium increase substantially, both in a relative and an absolute sense. Apparently congestion on roads and water in these countries lead to substitution towards rail.

Table 5. Quantities on the various paths in the network in 2025 for Scenario 1 (input Scenario 1 in 2000 = 100)

		Passenger	Local freight	Transit freight
Rotterdam-Ruhr	Road	1.55	1.49	1.45
	IWW	-	1.36	1.45
	Rail	1.58	1.76	1.69
	Betuwe	-	-	-
Antwerp-Ruhr	Road	1.61	1.56	1.60
	IWW	-	1.53	1.57
	Rail	1.63	1.69	1.73
Hamburg-Ruhr	Road	1.62	1.54	1.55
	IWW	-	1.59	1.60
	Rail	1.40	1.54	1.55

When looking more specifically at total freight flows to and from the three ports (see Table 6), we see a striking reduction in the competitive position of Rotterdam. This is especially true for transit freight, which partly switches to the ports of Antwerp and Hamburg. Apparently, congestion on the links from Rotterdam to the Ruhr area, and vice versa, become problematic in the future.

Table 6. Total quantities from or to Rotterdam, Antwerp and Hamburg in 2025 for Scenario 1 (input Scenario 1 in 2000 = 100)

	Passenger	Local freight	Transit freight
Rotterdam	1.56	1.48	1.49
Antwerp	1.61	1.57	1.60
Hamburg	1.52	1.54	1.55

Scenario 2

In Table 7 we present indexed transport flows in the year 2025 for scenario 2 compared to the output in 2025 for Scenario 1. Compared to 2000 the freight flows on the entire network in 2025 have increased by approximately 24% (not in table). When we compare this figure to the growth figures in scenario 1, marginal social cost pricing apparently causes a large reduction in transport flows. There furthermore is a striking shift from road and rail to waterway transport, likely because of the relatively limited maintenance costs for waterways. Furthermore, although total freight flows have decreased, the competitive positions of the three ports are similar to those in scenario 1 (not in Table). This is not entirely surprising since we have made almost no distinction in external costs between The Netherlands, Belgium and Germany. Only external costs of congestion are different between the three regions, but they apparently do not make a substantial contribution to total external costs per kilometer.

Table 7. Transport flows going to and from the three ports in 2025 for Scenario 2 (output Scenario 1 in 2025 = 100)

		Passenger	Local freight	Transit freight
Rotterdam-Ruhr	Road	0.88	0.78	0.75
	IWW	-	0.82	0.87
	Rail	0.89	0.84	0.80
	Betuwe	-	-	-
Antwerp-Ruhr	Road	0.93	0.82	0.83
	IWW	-	0.96	0.97
	Rail	0.94	0.81	0.82
Hamburg-Ruhr	Road	0.93	0.80	0.78
	IWW	-	1.03	1.00
	Rail	0.78	0.78	0.76

Scenario 3

In Table 8 we present indexed transport flows in the year 2025 for scenario 3. For Scenario 3the freight flows in 2025 have increased by approximately 55% compared to 2000 (not in table). Compared to an total increase of 52% in scenario 1 the additional freight link therefore has a slight positive effect on total freight transport. This is also expressed in the increase in transport flows along the Betuweroute (which is below the increase on other links because the reference year is 2008 instead of 2000).

The consequences of the Betuweroute for the port of Rotterdam in 2025 are large (see Table 9). The competitive position of Rotterdam now improves vis-à-vis Antwerp and Hamburg. However, this change in competitive position is a direct consequence of two central assumptions, i.e., our *assumption* that freight flows on the Betuweroute in 2008 resemble the transport flow estimates made by the Betuweroute operator, and our assumption that the distribution of freight to local and transit freight on the Betuweroute is identical to the distribution of freight flows on the existing rail link in 2000. In this view, the change in competitive position is there by construction, and may not be seen as pure output of the model.

Table 8. Quantities on the various paths in the network in 2025 for Scenario 3 (input Scenario 1 in 2000 = 100*)

		Passenger	Local freight	Transit freight
Rotterdam-Ruhr	Road	1.55	1.48	1.30
	IWW	-	1.36	1.12
	Rail	1.57	1.73	1.21
	Betuwe	-	1.49	1.45
Antwerp-Ruhr	Road	1.61	1.56	1.56
	IWW	-	1.53	1.53
	Rail	1.63	1.69	1.68
Hamburg-Ruhr	Road	1.62	1.54	1.51
	IWW	-	1.59	1.56
	Rail	1.40	1.54	1.51

* For the Betuweroute the quantities in 2008 are set at 100

For local freight the figures for Antwerp and Hamburg are identical to those in scenario 1, which makes sense since nothing has changed there locally. For Rotterdam, local freight has increased slightly vis-à-vis scenario 1 because of the Betuweroute. Transit freight has also increased for Rotterdam, which is for a large part due to a shift back from Antwerp and Hamburg. This shift cannot be observed from the tables directly. However, observe that if transit freight has increased on the entire network, then the decrease in Antwerp and Hamburg must have been more than offset by an increase in Rotterdam.

Table 9. Total quantities from or to Rotterdam, Antwerp and Hamburg in 2025 for Scenario 3 (input Scenario 1 in 2000 = 100)

	Passenger	Local freight	Transit freight
Rotterdam	1.56	1.50	1.63
Antwerp	1.62	1.57	1.56
Hamburg	1.52	1.54	1.51

Scenario 4

In Table 10 we present indexed transport flows in the year 2025 for scenario 4. Compared to 2000 freight flows on the entire network in 2025 have grown by approximately 27% (not in table). The freight figures are lower than under current pricing (scenario 1 and 3) but higher than in the scenario with marginal social cost pricing and without the Betuweroute (scenario 2). Again we see a substitution of freight transport from road and rail to water. Note that the figures (except those for the Betuweroute are almost identical to those under scenario 2. This implies that marginal social cost pricing in the situation with the Betuweroute has no additional effect on the competitive position of Rotterdam versus Antwerp and Hamburg.

Table 10. Quantities on the various paths in the network in 2025 for Scenario 4 (input Scenario 1 in 2000 = 100*)

		Passenger	Local freight	Transit freight
Rotterdam-Ruhr	Road	0.88	0.78	0.75
	IWW	-	0.82	0.88
	Rail	0.89	0.83	0.79
	Betuwe	-	0.91	0.87
Antwerp-Ruhr	Road	0.93	0.82	0.83
	IWW	-	0.96	0.97
	Rail	0.94	0.81	0.82
Hamburg-Ruhr	Road	0.93	0.80	0.78
	IWW	-	1.03	1.00
	Rail	0.78	0.78	0.76

* For the Betuweroute the quantities in 2008 are set at 100

8. Conclusions and discussion

The construction of the Betuweroute has been a heavily debated issue in The Netherlands. Even at the moment strong doubts exist with respect to its profitability and its potential to attract transport from other transport routes. In this paper we use the MOLINO model to analyse some of the potential consequences of construction and operation of the Betuweroute. We run the model from 2000 to 2025 and analyse transport flows and welfare effects using a specific transport network under four scenarios, i.e., with and without the Betuweroute, and under current pricing and marginal social cost pricing. The network includes transport from Rotterdam, Antwerp and Hamburg to the Ruhr area, and vice versa. By including a net growth of transport on each link of 2% per year we ensure that congestion is explicitly included in the analysis.

Under current prices and without the Betuweroute, freight flows on the entire network have increased with approximately 53% in 2025 vis-à-vis 2000. Compared to a maximum growth of 64% we may therefore conclude that congestion substantially reduces transport flows. We also see a striking reduction in the competitive position of the port of Rotterdam. This is especially true for transit freight, which partly switches to the ports of Antwerp and Hamburg. Especially the congestion on the links from Rotterdam to the Ruhr area appear to become problematic in the future. When marginal social cost pricing is introduced, thereby increasing the price of transport, freight transport on the entire network in 2025 is reduced even further, and the competitive position of Rotterdam does not improve. In the scenarios with the Betuweroute, freight on the entire network increases vis-à-vis the scenarios without the Betuweroute. This increase in generic freight transport is also expressed in the substantial increase in transport flows on the Betuweroute itself. Also striking are the consequences of the Betuweroute for the port of Rotterdam in 2025, the competitive position of which has now increased vis-à-vis Antwerp and Hamburg in 2025.

The welfare consequences of introducing marginal social costs pricing are according to expectation; passenger user surplus goes down because transport demand decreases, toll revenues increase, external costs drop substantially, and social welfare increases. With respect to the general welfare consequences of the Betuweroute, although unit toll is higher than unit variable costs of operation and maintenance, toll revenues are not nearly enough to cover total costs of operation and maintenance. Together with the substantial investment costs this leads to a drop in social welfare.

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