Intermodality and Substitution of Modes for Freight Transportation : Computation of Price-Elasticities through a Geographic Multimodal Transportation Network Analysis

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Abstract

In order to limit the external costs caused by the use of trucks (pollution, congestion, …), multi- and intermodal transport are promoted in various ways. One way to partly shift transport demand on trains and barges is to introduce a pricing/taxation policy which takes into account these external costs for the different modes. The effects of such a policy are obviously dependent upon the way demand for the various modes is sensitive to variation of tariffs. There are very few estimates of direct and crossed price-elasticities available in the literature, particularly if different markets, i.e. different categories of goods, are taken into account. Moreover, existing estimates are obtained through sophisticated yet conventional statistical methods that do not directly cope with the topology of a given network.

This paper presents estimates which have been computed for ten different categories of goods with a detailed multimodal network model based on a particular methodology that permits a thorough analysis of intermodality and modal substitution. Assigned flows obtained with different levels of relative costs for the different transportation modes are used to compute direct and cross arc-elasticities over a concrete real digitised network. The computed elasticities are then discussed and compared to previously published estimates.

1 Introduction

The strong expansion of freight road transportation throughout Europe is an important source of congestion and pollution, as well as a cause of many accidents. It is most likely that this problem will grow worse as it is expected that freight traffic will go on increasing over the coming years. A often proposed partial solution to this problem would be the promotion of transportation modes which have lesser negative effects, i.e. rail and waterway, as well as their intermodal combination with road, in order to substitute these modes to the use of direct road transport. One way to obtain such a result would be to apply a pricing/taxation policy which takes into account the external costs of the different modes.

While such a policy is worth considering in principle, because it would promote a better allocation of collective resources, its effects are dependent upon the way demand for the various modes reacts to tariffs' variations. Measures of the modes' demand direct and cross-elasticities with respect to prices would provide some valuable information about what effect could be expected, but very few estimates of such elasticities are available in the literature, particularly if different markets for transportation, i.e. different categories of goods, are taken into account. Moreover, the existing estimates, like those recently published by Abdelwahab (1998) are obtained from sophisticated yet conventional statistical methods which do not take explicitly into account the particularities of a real network topology, such as a convenient accessibility at some points in space to alternative transportation modes, which depends on the existence of specific infrastructures (rail tracks, canals, etc.).

In this paper, we present estimates of elasticities which have been obtained from a detailed multimodal network model of freight transportation in Belgium through a set of simulations made with different cost parameters for ten different categories of goods[1]. This model of the Belgian railways, waterways and roads network embedded within the European networks is based on the NODUS virtual network software[2], which takes into account separately each specific transport operation (loading, transiting, transhipping, etc.) and their costs. Given the matrix of origins and destinations, it minimises the generalised cost of the corresponding transportation task by an optimal assignment of the flows between modes, vehicles, or their combination, and routes. Hence, it permits a thorough analysis of intermodality and modal substitution through simulations. In this way it is possible to generate direct and cross arc-elasticities with respect to cost variations, which fully takes into account the spatial characteristics of the network. These network elasticities are somewhat unusual, and their assessment requires a good understanding of their particular character compared to the usual statistically derived elasticities.

In Section 2, the paper starts with some methodological considerations. First, section 2.1 compares network elasticities with the other more usual elasticities; then, section 2.2 explains some basic elements of the multimodal transport model and how it was built up over the Belgian network. Section 3 presents the elasticities obtained from a set of simulations with the

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[1] Part of this paper is based on the results of a research contract with the " des Transports de la Région Wallonne". The substantial work of building the matrix of origins and destinations was made by the consultant STRATEC S.A. (Brussels).

[2] Presented in Jourquin (1995), Jourquin and Beuthe (1996), and further developed in Deliverable D5 (1998) of the TERMINET Research Programme funded by the European Commission.

network model and compares them with those published in the litterature. A global assessment of the results concludes the paper.

2 Methodological considerations

2.1 Elasticities in freight transport

Before explaining in some details the features of the transport model which is used to obtain measures of transport demand elasticities, it is necessary to briefly review the different types of price elasticities which may be found in the freight transport literature[3]. The first main distinction must be made between ordinary and conditional elasticities. The former measure the combined substitution and scale or output effect of a price change; the latter is akin to the compensated demand elasticity in the consumer theory and is conditional on a given level of output. In their survey Oum et al. (1992) found out that it was not always easy to identify the type of elasticity which was presented in the literature. They propose to regard an elasticity as conditional if the shippers' output is included in the demand equation.

All the published measures of freight transport elasticity that we know of were obtained from econometric estimation, either on the basis of time series or cross-section data. Cross-section data usually do not give information about outputs, so that the corresponding estimates are not normally of the conditional type. There are aggregate market elasticities and mode-specific elasticities. In this paper we focus on the latter which, most often, are based on a modal-split analysis. Such elasticities can be estimated from aggregate or disaggregate data. In both cases, they are unable in practice to take into account the effect of a price change on the aggregate volume of traffic and would need to be adjusted in order to obtain the regular demand elasticity (Taplin, 1982, Quandt, 1968, and Oum et al., 1992). Elasticities obtained with a discrete choice model from aggregate data on volume shares underestimate somewhat the response of the shippers to price changes (Winston, 1979). Whenever possible, it is thus preferable to proceed with disaggregate data on individual shippers' choices. In this case, the computed individual elasticities must be aggregated over the sample to obtain a mode's market demand elasticity. A recently published example of such an approach is given by Abdelwahad (1998).

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[3] A very good survey of the different methodologies used to derive elasticities in the field of transportation can be found in Oum et al. (1992). See also Winston (1985) and Zlatoper and Austrian (1989).

Finally, we must mention the distinction between traffic and transport demand elasticities. Björner (1999), focusing on the environmental impacts of road transports, is somewhat more interested by the variation of traffic, i.e. kilometres realised by trucks, rather than by transport in tons/km as it is usually the case. In effect, it is the most relevant variable from an environmental point of view. Traffic is then taken as one of several inputs in the shippers production of transport services, while transport demand is derived from the firms' production of output and depends not only on transport cost per ton/km, but also on the spatial location of transported inputs, their weight and their prices. Hence, the impacts of a transport cost variation may vary from one commodity to another. Furthermore, since there can be some substitution between different transport production inputs, e.g. administration, information, capital resources, traffic, etc., the price-elasticity of traffic can be different from the transport elasticity. Actually, it could very well be stronger, and that is what is found out in this empirical study.

The next section will provide more details on the transport model which was used to derive our estimates, but we can already, through its general description, define the type of elasticity obtained with reference to the above distinctions. The model is not an econometric one but a GIS based model of the multimodal freight network of Belgium embedded within the trans-European network. As outlined in the introduction, given a point-to-point O-D matrix per group of commodities, it assigns the transport flows to the cheapest combination of modes, means and routes. After a proper calibration of the model by means of the cost functions with respect to observed flows, sensitivity analyses applied to cost parameters allow to assess their impacts on the mode's market shares and to compute tons and tons/km arc-elasticities.

Thus, since the same O-D matrixes are used for all the simulations, the computed network arc-elasticities per group of commodities are of the conditional type for a given transport task. The estimates are based on a "all-or-nothing" assignment procedure of the flow between each pair of origin and destination, so that these elasticities are aggregates of "individual" responses. They fully take into account the spatial configuration of the networks, the specific characteristics of the different O-D matrixes, and the inventory cost of the different commodities. In effect, the cost variations simulated in order to generate the arc-elasticities bear upon the generalised cost of transport, which implies that they cannot be taken as usual price elasticities but rather as "generalised cost elasticities". This means that these measures cumulate the effects of the factors included in the generalised cost which is assumed to determine the shippers' choice, in this case not only the monetary cost but also, to some extent, the value of time for the shippers. On the other hand, since the variations of costs are fully controlled through the simulations, the *ceteris paribus* condition is fully respected, and these elasticities measure the impacts of a mode's cost variation on modal shares in the absence of any competitive adjustments by the other modes.

Another important point is that, even though the model has been calibrated on observed data, the measures are not derived from statistically adjusted response functions but from an optimal transport choice model. If this model approximates well enough the choice behaviour of the shippers at least in the long run, this implies that these measures reflect, *ceteris paribus*, long run responses rather than short run ones, since choice adjustments are postulated to be made instantaneously in the simulations. The methodology allows to compute elasticities with respect to tons/km as well as with respect to tons, hence, will allow to check Björner's result. Obviously, some additional comments will be given after a more detailed explanation of the transport model and a review of the empirical results.

2.2 Inter - and multimodality in freight transport networks

A thorough analysis of freight transportation over a network, with all its alternative solutions, requires a separate identification of the different operations in a transportation chain. In the NODUS network model all the modes and means of transportation but also all the loading, unloading, transhipping and transiting operations are identified and associated with a "virtual link". A fictitious expanded multimodal network, or "virtual network", is automatically generated by NODUS on the basis of the characteristics of the underlying geographical network. In the present case, there are about 17,000 geographical links (digitised network) from which a virtual network of about 265,000 virtual links is generated.

Appropriate cost functions (see section 2.3) are attached to each virtual link defined by a specific transport operation. Then, given an O-D matrix, it is possible to minimise the corresponding total generalised cost of transportation with respect to, simultaneously, the choices of modes, means and routes, including intermodal combinations. The resulting assignments can be taken as estimates of transport demand for the different modes and means under two hypotheses : that the shippers are actually minimising the generalised cost of transportation, and that the (unknown) carriers' tariffs bear a close relationship with the operating transport cost, at least at the margin for 'contestable' transports. Both hypotheses can be debated. But, even if they are accepted as good approximations, the results must still be interpreted with caution because some information, such as relative safety, reliability or other services characterising the different transport solutions were not available and therefore not specifically included. In order to compensate this lack of information, the model was calibrated as far as it was possible on observed flows on main links and modal shares.

2.3 Cost functions on virtual networks

2.3.1 General framework

Various types of objective functions can be used with NODUS. In this case, the total generalised cost of transportation on the network was minimized. This total cost, which must be minimized with respect to the choices of modes (*t*), means (*m*), and routes (*l*), can be defined as $TC = \sum_l \sum_t \sum_m TC_{ltm}$, where TC_{ltm} is the sub-total cost for the traffic on a particular route *l* with mode *t* and mean *m.* TC_{ltm} is the sum of all the costs over the successive links (or operations) of the virtual network over route *l*, and it is supposed that all these costs are proportional to the total quantity transported Q_{ltm}.

Assuming further that all the costs per ton for a link *j* are either constant or proportional to the distance s_j, we can write :

$$TC = \sum_l \sum_t \sum_m Q_{ltm} \left(\sum_{j \in l} A^{tmj} + \sum_{j \in l} B^{tm} s_j \right),$$

where s_j is the distance over the link *j*. This is the total cost which must be minimised with respect to *l, t,* and *m.* After attaching the relevant cost functions to all the links, this operation is realised by applying Johnson's algorithm (1973), an optimised[4] version of the well known algorithms of Moore (1957) or Dijkstra (1959), onto the virtual network.

This general framework being defined, we can now have a closer look at the various cost functions which are used on the network: the vehicles related costs, the handling costs and the commodities' inventory costs. The cost data were collected through numerous sources; they are all listed and thoroughly discussed in Jourquin (1995) .

2.3.2 Vehicle's related costs

For a given link, the vehicles' costs for transporting one ton over a distance s by mode *t* and mean *m* are taken to be a linear function of distance s :$A^{tm} + B^{tm}.s$. The constant A^{tm} corresponds to the fixed costs incurred for the vehicles and the crew during the (un)loading and transhipping operations . It is based on capital annuities, insurance, maintenance costs and wages.

The duration of the handling operations are estimated by the Deming's (1978) formula whereby handling-time = a + b * (quantity) ^{c}, a non-linear relation between handling time and handled quantity.

The cost of moving one ton over a distance *s* is proportional to that distance, as B^{tm}, the cost per km, is a constant. B^{tm} includes the same parameters as those indicated above, but is also a function of average speed, fuel consumption and loading rate. Note that the real distance on a some links is adjusted to take into account various delays and congestion which are usually encountered on them.

2.3.3 Other handling costs

Beside these vehicles' costs, we have taken into account the labor costs of handling the goods at the points of origin and destination, or when the goods are transferred from one mode or means to another. The estimation of the time needed for these operations is based on the same formula as above. There may be also some other costs related to delays, administrative paperwork or even congestion at some points of the network. These additional costs are included as additional constant costs at some nodes and/or links. Some additional links in the virtual network have also been introduced in order to take into account costs of some particular operations, such as the crossing of a national boundary. These are simple transit costs.

2.3.4 Opportunity cost

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[4] The algorithm of Johnson gives faster results on low-density networks, i.e. in which the number of links ≈ number of nodes, as on most geographic networks.

It is the opportunity cost of the capital tied into the goods during transportation. This cost is proportional to the total time needed by the transportation chain. Its importance varies with the rate of interest and the value of the goods.

3 Reference model and calibration

The model of the actual freight flows inside and through Belgium in 1995, the “reference scenario” was set-up in three steps:

1. First, surveys of shippers and traffic observations along the network were used, along with aggregated published statistical data, to create detailed origin-destination matrixes for each mode and for the ten groups of NST-R commodities. Inside Belgium the cities were used as centroïds because information was gathered at a sufficient level of disaggregation. Outside the country, data were only available at the aggregate level of NUTS3 or NUTS2 regions[5] which contain more than one city. This problem was solved by assigning the transport flows among the different cities by means of a Monte-Carlo procedure. The resulting matrixes provided useful information for defining some attributes of the networks : along the waterways, no loading and unloading operations were allowed for certain commodities in ports where no such movements were observed; the same kind of exclusion was introduced at some railway stations in order to forbid the handling of block trains at some stations.
2. Through cost minimisation, all these matrixes were then assigned mode per mode over the corresponding network and the aggregated estimated flows were compared to the counts observed along the roads, railways and waterways. This step was very helpful for checking the digitised networks and the attributes of the nodes and links. Speeds on some links could for example be adjusted in order to reorient some flows and obtain a better fit between some computed and observed flows, particularly in the periphery of large cities.
3. At that stage the matrixes relative to each freight transportation mode were merged to obtain ten matrixes corresponding to the different groups of commodities. They were used to assign the transport flows simultaneously to the modes, means and routes through cost minimisation. As, in our O-D matrixes, a centroïd corresponds to a city and that on the digitised network these centroïds are directly connected to the different transport

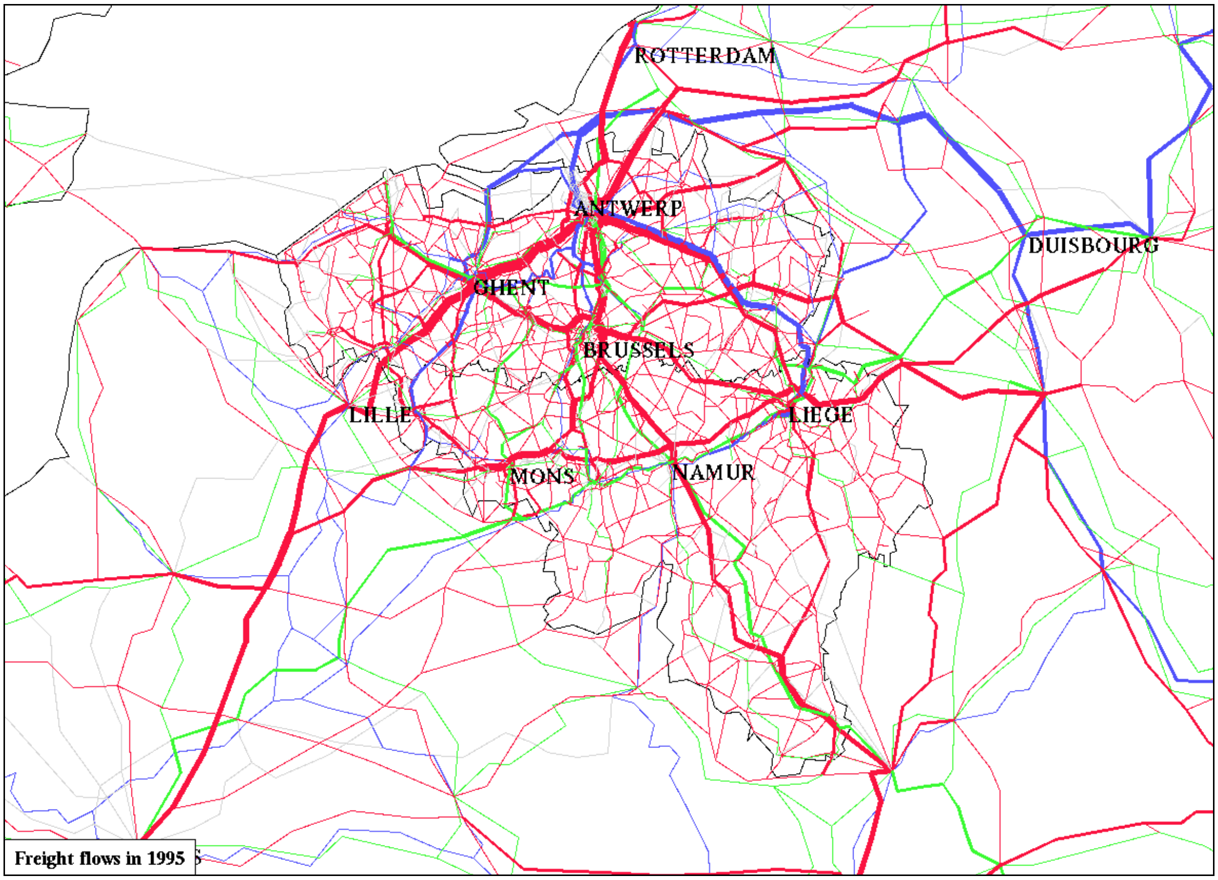
infrastructures available at the city level, i.e. roads, railways and/or inland waterways, a last problem remained to be solved. Indeed, all the producers and customers in a city aren't necessarily located at the railway station or the inland port and, thus, need some initial or final trucking to/from these facilities. To solve this, some average additional fixed costs, used to calibrate the model, were added to the (un)loading operations in order to reflect this additional link in the transportation chain.

As explained above, the model assigns the flows not only to a mode, but also to a transportation means. In this application, the model performed rather well in identifying the types of boat used (300 tons, 600 tons, 1350 tons and 2000 tons or more) on the basis of their different cost functions, the capacity of each inland waterway and the exclusions mentioned above. Likewise, the information about exclusions and cost functions included in the model allowed satisfying assignments between block trains and traditional trains. Unfortunately, the use of different cost functions for small and large trucks (7 tons and 40 tons respectively) did not lead to correct choices between these two means, the reason being that both types of trucks are used for long and short hauls according to the size of the shipments, and no information that could be included in the model was available about shipment sizes. This problem was solved by splitting total road flows between small and large trucks on the basis of external information about the distribution of the use of small and large trucks with respect to travel distance.

Table 1 compares the results of the assignments realised by the model with the 1995 data on observed modal choices. Map 1 illustrates the flows on the Belgian territory, on which the red lines correspond to truck flows, the green lines to the rail flows and the blue ones to the waterways flows.

Map 1 : Assigned flows on the Belgian freight network (reference scenario)

[5] NUTS3 data were obtained for regions nearby Belgium.



Another way to assess the model performance is to compute the correlation between the observed flows and those assigned by the model at various points on the network. A correlation coefficient of 0.92 was obtained for waterway flows, 0.86 for railways, and 0.91 for roads.

Table 1 : Assignment performance (tons)

	Observed (1995)		**Estimated**	
Group	**Water**	**Rail**	**Water**	**Rail**
0-9	**11.28%**	**8.99%**	**11.06%**	**9.05%**
0	7.18%	2.24%	7.56%	1.67%
1	5.06%	2.44%	5.61%	2.13%
2	25.33%	43.51%	25.11%	43.81%
3	28.65%	6.23%	28.89%	9.08%
4	25.06%	49.07%	18.66%	50.24%
5	7.44%	26.22%	7.32%	26.77%
6	15.37%	1.74%	15.44%	1.33%
7	23.70%	5.25%	24.09%	5.39%
8	8.00%	6.56%	7.85%	6.05%
9	0.53%	11.40%	0.88%	11.35%

4 Model results and discussion

Once the calibrated reference scenario was obtained, a set of different simulations could be performed in which some elements of the modes' cost functions were modified. In the first set, the total transportation cost for each mode separately was modified; these costs were decreased and increased successively by 2, 5 and 10 percents of the reference level. As three modes were involved, the first set contains 18 different assignments[6]. In order to separate the impact of the direct transport costs from the other costs of handling, transhipping and transiting, a second set of assignments was produced, in which only the "moving costs" were reduced by 5 percent for each mode successively. A third set was made to assess the influence of travel distances on the measured elasticities. For doing so, the O-D matrixes were split into short and long haul transports (> 300 km). Assignments were computed for both types of matrixes when the total transportation costs were decreased by 5 percent for each mode successively. On the basis of the results obtained from these simulations, the corresponding elasticities were computed by means of the following formula, where output can be introduced in tons (quantity) or tons/km (flow).

$$\varepsilon^{j}_{m1,m2} = \frac{\text{ReferenceOutput}^{j}_{m2} - \text{NewOutput}^{j}_{m2}}{\text{ReferenceCost}^{j}_{m1} - \text{NewCost}^{j}_{m1}} * \frac{\text{ReferenceCost}^{j}_{m1} + \text{NewCost}^{j}_{m1}}{\text{ReferenceOutput}^{j}_{m2} + \text{NewOutput}^{j}_{m2}}$$

where:

ε : elasticity

j : group of commodities

m1 : transport mode 1

m2 : transport mode 2

Table 2 gives all the aggregate elasticities computed with respect to tons and tons/km when costs are reduced by 5%. Table 3 gives all the ton/km elasticities per group of goods for the same relative change of the costs. The extensive set of results obtained with other relative cost variations can be found in Table 5 in the Appendix, in which some variations of elasticities with the magnitude of the cost variation can be observed. This is inherent in this concept of elasticity which takes into account the topology of the networks and the localisation of activities. But, altogether, they are rather stable.

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[6] Note that the fixed costs introduced to simulate initial and final trucking (see step 3 of the model calibration) were kept constant.

Table 2: Aggregate elasticities when costs are reduced by 5%

		Set 1 Total cost reduction			Set 2 Travel costs reduction			Set 3 (total cost variation) Short distances			Set 3 (total cost variation) Long distances		
		Road	**Rail**	**Water**	**Road**	**Rail**	**Water**	**Road**	**Rail**	**Water**	**Road**	**Rail**	**Water**
Tons	**Road**	-0.63	0.17	0.16	-0.44	0.12	0.06	-0.57	0.16	0.15	-1.03	0.15	0.12
	Rail	1.75	-1.56	1.54	1.35	-1.22	0.76	2.10	-2.77	2.07	1.58	-0.95	0.50
	Water	2.64	0.82	-2.94	1.75	0.67	-1.42	3.53	1.52	-3.01	1.01	0.59	-1.30
T/km	**Road**	-1.28	0.51	0.11	-1.03	0.46	0.05	-0.84	0.36	0.10	-1.64	0.71	0.09
	Rail	1.24	-0.81	0.71	1.03	-0.72	0.53	2.08	-2.87	1.70	1.11	-0.64	0.43
	Water	1.29	0.57	-2.16	0.94	0.46	-1.65	2.60	1.66	-2.01	0.78	0.48	-1.59

Altogether, it can be observed that most of the obtained elasticities are of the same order of magnitude than those which can be found in the literature. However, some of them are definitely stronger while some others are extremely small. This can be explained by different reasons:

- The model assigns the flows on a real network which has a particular topology with the three transportation modes competing on most routes. Such a high density of the three modes' networks is an important characteristic of the studied area.
- The flows are assigned by an all-or-nothing assignment procedure that minimises the total generalised cost. As explained in section 2, the elasticities are measured under the *ceteris paribus* condition without any competitive reaction which could attenuate the cost variation effect. Moreover, they result from assignments made under assumption of a complete instantaneous adjustment to the new cost situation.

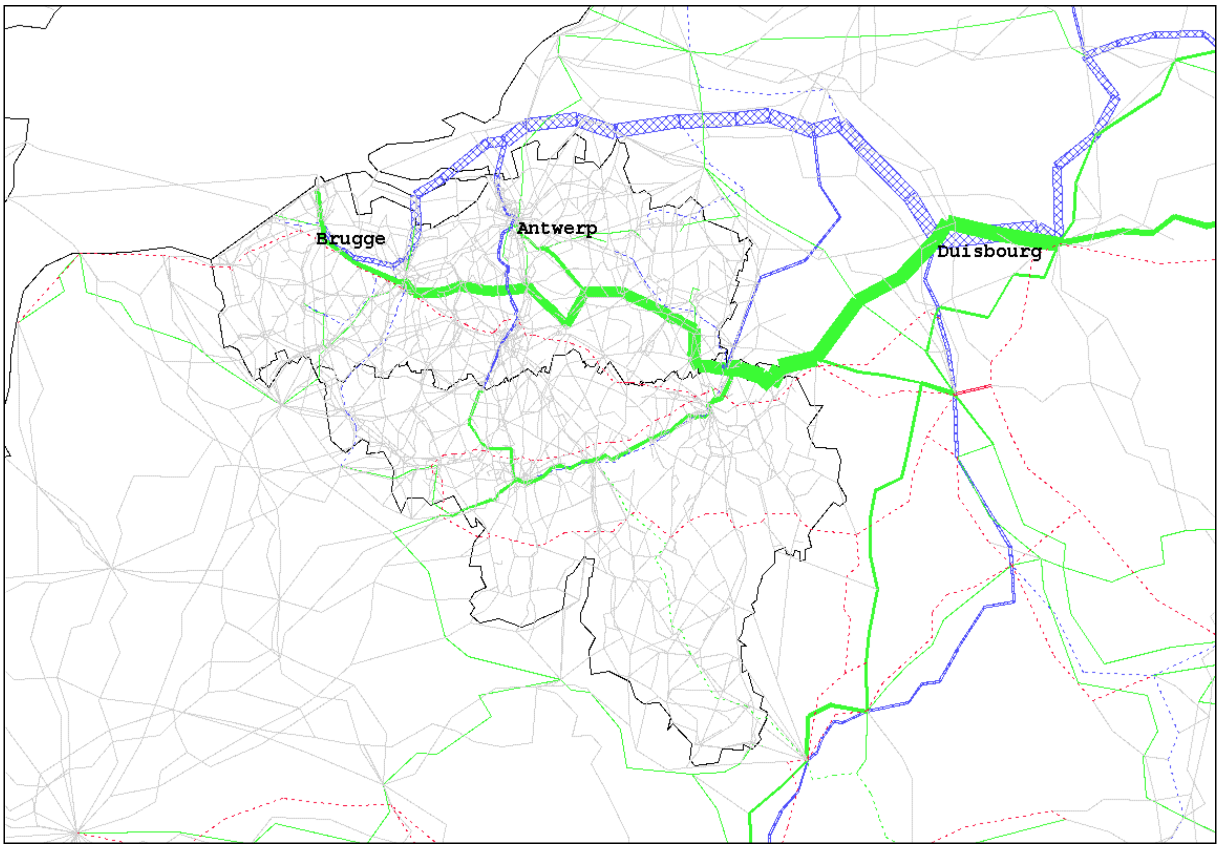
Table 3: Computed tons/km elasticities per group of commodities when the costs are reduced by 5%

		Set 1 Total cost variation			Set 2 Travel costs variation			Set 3 (total cost variation) Short distances			Set 3 (total cost variation) Long distances		
NST-R		**Road**	**Rail**	**Water**	**Road**	**Rail**	**Water**	**Road**	**Rail**	**Water**	**Road**	**Rail**	**Water**
0	**Road**	-1.82	0.42	0.06	-1.09	0.31	0.05	-0.61	0.31	0.03	-2.72	0.69	0.08
	Rail	1.08	-0.52	0.27	0.45	-0.43	0.26	3.84	-4.68	0.16	0.96	-0.56	0.19
	Water	3.27	0.91	-1.53	3.17	0.90	-1.48	10.33	0.14	-0.70	2.58	1.60	-1.02
1	**Road**	-0.64	0.14	0.24	-0.51	0.13	0.12	-0.29	0.01	0.33	-1.15	0.16	0.14
	Rail	0.79	-0.34	0.78	0.57	-0.30	0.74	2.42	-1.28	1.86	0.81	-0.17	0.72
	Water	1.58	0.13	-2.81	1.40	0.09	-2.29	4.00	0.88	-5.59	1.18	0.05	-2.22
2	**Road**	-0.24	0.00	1.45	-0.04	0.00	1.15	-0.47	0.00	2.65	0.00	0.00	0.00
	Rail	0.01	-0.47	1.08	0.00	-0.46	1.03	0.03	-0.21	1.18	0.00	-1.05	0.90
	Water	0.05	1.72	-3.94	0.03	1.72	-3.64	0.07	0.72	-4.25	0.00	4.64	-3.09
3	**Road**	-0.87	0.02	0.05	-0.61	0.01	0.02	-1.77	0.04	0.10	0.00	0.00	0.00
	Rail	0.59	-0.28	2.03	0.44	-0.23	0.12	1.09	-2.52	0.17	0.00	-0.43	1.49
	Water	0.79	0.44	-2.67	0.45	0.38	-0.20	1.80	4.41	-0.39	0.00	0.53	-1.72
4	**Road**	-0.32	2.63	0.05	-0.15	0.04	0.04	-1.91	1.71	0.06	0.00	0.00	0.00
	Rail	0.04	-0.75	5.50	0.02	-0.09	2.49	0.53	-0.40	3.39	0.00	-0.18	0.10
	Water	0.07	0.26	-10.3	0.02	0.23	-7.28	0.11	0.14	-6.14	0.00	0.39	-0.21
5	**Road**	-3.12	1.38	0.22	-2.69	1.20	0.10	-2.26	3.51	0.27	-2.90	0.15	0.15
	Rail	2.14	-1.48	1.40	1.81	-1.33	1.29	8.08	-10.4	2.50	1.10	-0.43	1.30
	Water	2.10	4.45	-8.38	1.72	4.05	-7.68	6.16	7.66	-6.47	0.72	3.33	-9.07
6	**Road**	-0.91	0.18	-0.09	-0.65	0.17	-0.17	-1.23	0.07	-0.19	-0.03	0.00	-0.04
	Rail	0.60	-0.80	0.51	0.43	-0.57	0.49	3.32	-2.57	2.04	0.00	-0.01	0.12
	Water	0.57	0.31	-0.16	0.40	0.17	-0.07	1.97	1.53	-0.42	0.01	0.00	-0.05
7	**Road**	-1.33	0.00	0.22	-0.39	0.00	0.11	-1.48	0.00	0.28	-0.53	0.00	0.00
	Rail	0.12	-0.09	0.14	0.05	-0.09	0.05	0.43	-0.35	0.31	0.00	-0.09	0.07
	Water	0.70	0.13	-0.32	0.26	0.12	-0.14	2.34	0.33	-0.75	0.17	0.13	-0.11
8	**Road**	-1.27	0.13	0.19	-0.92	0.12	0.14	-0.42	0.01	0.15	-1.77	0.21	0.22
	Rail	1.62	-0.28	0.09	1.49	-0.25	0.09	5.42	-2.40	0.44	1.57	-0.25	0.08
	Water	3.12	0.09	-1.56	1.01	0.09	-1.26	4.17	0.51	-1.91	2.88	0.00	-1.48
9	**Road**	-1.19	0.86	0.05	-1.16	0.84	0.04	-0.30	0.03	0.07	-1.56	1.28	0.04
	Rail	1.63	-1.16	0.29	1.60	-1.12	0.29	0.16	-3.62	0.21	1.66	-1.21	0.30
	Water	7.06	0.78	-10.0	6.50	0.28	-9.83	28.70	0.26	-3.45	2.86	1.05	-11.7

- All of the elasticities with a very high values indicate modal shifts on major O-D pairs for a particular group of commodities. It is particularly the case for elasticities with respect to waterways and railways costs. For instance, Map 2 illustrates the 4.65 value of Table 5 (Rail-Water cross elasticity, in tons, for long distance transport of NST 5 when the total costs of railway transport are reduced by 5%): A clear modal shift from waterways (dashed blue lines) onto railways (plain green line) can be observed between Brugge and Duisburg. As this represents a high volume of traffic inside the NST 5 O-D matrix, this modal shift has a very important impact on the computed elasticity.

- In the same way, very high values are obtained for waterway transport of NST 9 (diverse commodities). This can be explained by the very small modal share of this transportation mode for these goods (less than 1%) : some, even small, additional traffic obtained by a cost reduction can represent a relative big gain for barge transport.

Map 2: Modal shift on the Brugge-Duisburg route (NST 5)



We note that the elasticities obtained when all the transport costs are modified are higher than those computed when only the travel costs are changed. This could be expected and is explained by the importance of the loading and unloading costs in the total transportation costs.

For railways and inland waterways, all elasticities computed on the basis of the transported tons are higher than those calculated on the produced tons/km. That makes sense because these transportation modes are more competitive over long distances : any change in their transportation cost will more directly affect their market-share on shorter distances, making the relative change in the total quantity transported more important than the relative change in the produced tons/km. Likewise, the direct elasticities obtained for rail and water transport are higher for short distances than for long trips. An additional reason for this is the low market-share of these two modes on shorter hauls.

A reverse relationship is observed for road elasticities : with the exception of elasticities with respect to waterways' costs, the tons/km elasticities are higher than those computed on the basis of transported tons. This outcome confirms Björner's (1999) result who found a "traffic" elasticity of –0.8 while the tons/km elasticity was –0.47. Like in his case where an adjustment of mileage realised explains the stronger "traffic" elasticity, it is the mileage adjustment which produces a stronger elasticity of tons/km when compared to the one based on tons transported. Note also that the short distances direct road elasticities are smaller than the long distance ones.

Table 4: Comparison with other published elasticities

STCC	NST-R	Elasticity	Abdelwahab[7]	Jourquin et al.[8]
33: Primary metal products 34 : Fabricated metal products	5 : Metal products	Truck-Truck	-0.80 → -2.18	-2.13
		Rail-Rail	-0.91 → -2.49	-3.32
		Rail-Truck	0.90 → 2.42	3.72
		Truck-Rail	0.93 → 2.53	1.23

Table 4 compares some of these elasticities with those published by Abdelwahab (1998). As the categories of goods used in both papers are not directly comparable, the comparison is limited to two groups that are more or less identical, i.e. STCC 33/34 and NST-R 5. In this case, the values obtained in this paper appear to be slightly higher than those of Abdelwahab (1998).

[7] Elasticities were computed for different regions. This column gives the lowest and highest obtained values.
[8] These values are obtained with a reduction of 5% of the total transportation costs.

5 Conclusions

This paper has presented a whole set of direct and cross-elasticities for road, rail and waterway freight transport computed by means of a multimodal network model applied to different groups of goods. Section 2 gives an overview of the recent literature, and discusses the nature of the elasticities that are computed in our simulations.

Compared to other studies, the values that are obtained are, in most cases, of the same order of magnitude. However, the estimated values differ according to the group of goods analysed, and some elasticities can be very high while some others are extremely low. This is due to several factors: the strict application of the *ceteris paribus* condition in the simulation; the particular topology of the region and its network of three competing modes; the different spatial localisation of transport demand for the various categories of goods; the all-or-nothing assignment procedure based on cost minimisation which produces "ideal" results akin to a long run partial equilibrium outcome.

Thus, these elasticities need to be properly understood and assessed before being used in a different regional context. Contingent on this reservation, they appear to be highly relevant. Thus, the proposed methodology based on a multimodal spatial simulation model has shown itself to be particularly useful in that it is able to produce complete sets of direct and cross-elasticities for different groups of commodities and to distinguish between different types of elasticities, i.e. between elasticities related to short and long haul transports and according to the cost parameters which are affected.

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Appendix

Table 5 : Elasticities for different relative costs

		SET 1																		SET 2			SET 3 (total cost variation)					
		Total transportation costs variation																		Travel costs var.			Short distances			Long distances		
		Road						Rail						Water						Road	Rail	Wat.	Road	Rail	Wat.	Road	Rail	Wa
ST 0-9	*Rel. cost*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.65	-0.63	-0.66	-0.87	-0.73	-0.66	0.12	0.17	0.23	0.14	0.12	0.10	0.15	0.16	0.18	0.15	0.12	0.12	-0.44	0.12	0.06	-0.57	0.16	0.15	-1.03	0.15	0.1
	Rail	1.95	1.75	1.87	2.54	1.91	1.55	-1.30	-1.56	-2.11	-2.31	-1.82	-1.70	1.37	1.54	1.32	1.00	0.78	0.83	1.35	-1.22	0.76	2.10	-2.77	2.07	1.58	-0.95	0.5
	Water	2.93	2.64	2.65	2.79	2.43	2.18	0.96	0.82	1.26	1.81	1.31	1.26	-2.47	-2.94	-3.03	-2.58	-2.11	-2.34	1.75	0.67	-1.42	3.53	1.52	-3.01	1.01	0.59	-1.3
/km	**Road**	-1.24	-1.28	-1.30	-1.48	-1.39	-1.22	0.41	0.51	0.54	0.60	0.44	0.36	0.13	0.11	0.14	0.13	0.11	0.11	-1.03	0.46	0.05	-0.84	0.36	0.10	-1.64	0.71	0.0
	Rail	1.25	1.24	1.25	1.40	1.17	0.94	-0.78	-0.81	-0.95	-1.47	-1.14	-1.01	0.56	0.71	0.72	0.31	0.27	0.37	1.03	-0.72	0.53	2.08	-2.87	1.70	1.11	-0.64	0.4
	Water	1.38	1.29	1.09	1.05	1.16	1.09	0.96	0.57	0.77	1.80	1.48	1.25	-1.71	-2.16	-2.20	-1.31	-1.14	-1.58	0.94	0.46	-1.65	2.60	1.66	-2.01	0.78	0.48	-1.5
ST 0	*Rel. Cost*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.69	-0.93	-0.77	-0.51	-0.59	-0.71	0.16	0.21	0.09	0.18	0.14	0.13	0.08	0.05	0.06	0.02	0.11	0.12	-0.65	0.15	0.03	-0.37	0.12	0.03	-3.76	1.08	0.1
	Rail	2.33	2.77	2.27	1.82	1.83	1.57	-0.94	-1.27	-1.24	-1.34	-1.15	-1.01	0.57	0.46	0.53	0.89	0.39	0.23	1.38	-1.03	0.44	4.59	-2.75	0.16	2.19	-1.45	0.3
	Water	3.57	5.03	3.50	1.18	1.80	3.12	0.77	1.00	2.25	1.26	1.18	0.93	-2.10	-1.64	-2.01	-2.63	-2.41	-2.27	4.78	0.99	-1.45	10.08	0.24	-1.40	3.54	1.90	-1.0
/km	**Road**	-1.17	-1.82	-1.09	-0.94	-0.90	-1.16	0.27	0.42	0.18	0.28	0.22	0.21	0.10	0.06	0.09	0.02	0.17	0.20	-1.09	0.31	0.05	-0.61	0.31	0.03	-2.72	0.69	0.0
	Rail	0.71	1.08	0.56	0.69	0.57	0.53	-0.35	-0.52	-0.46	-0.50	-0.48	-0.41	0.35	0.27	0.39	0.33	0.16	0.10	0.45	-0.43	0.26	3.84	-4.68	0.16	0.96	-0.56	0.1
	Water	2.19	3.27	2.16	0.54	0.80	1.44	0.71	0.91	1.97	1.24	1.34	1.00	-1.85	-1.53	-2.05	-2.17	-1.82	-1.65	3.17	0.90	-1.48	10.33	0.14	-0.70	2.58	1.60	-1.0
ST 1	*Rel. Cost*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.52	-0.40	-0.37	-1.33	-0.91	-0.71	0.06	0.06	0.13	0.06	0.04	0.05	0.28	0.40	0.06	0.16	0.13	0.11	-0.29	0.06	0.12	-0.31	0.01	0.42	-1.25	0.23	0.2
	Rail	1.90	1.77	0.97	2.30	2.61	2.18	-1.13	-0.98	-1.47	-1.34	-1.03	-1.19	0.64	0.97	0.48	0.72	0.53	0.64	1.03	-0.83	0.72	3.71	-1.54	1.82	1.37	-0.40	0.6
	Water	5.62	3.05	3.39	11.43	6.23	4.28	0.78	0.47	0.15	0.79	0.70	0.68	-3.34	-5.04	-1.22	-2.91	-2.37	-2.30	2.51	0.33	-2.09	4.69	0.93	-7.77	1.47	0.05	-1.6
/km	**Road**	-1.05	-0.64	-0.43	-1.39	-1.38	-1.05	0.14	0.14	0.30	0.16	0.09	0.13	0.23	0.24	0.05	0.11	0.12	0.12	-0.51	0.13	0.12	-0.29	0.01	0.33	-1.15	0.16	0.1
	Rail	0.89	0.79	0.44	1.21	1.48	1.08	-0.41	-0.34	-0.63	-0.52	-0.45	-0.73	0.45	0.78	0.15	0.10	0.12	0.14	0.57	-0.30	0.74	2.42	-1.28	1.86	0.81	-0.17	0.7
	Water	4.18	1.58	1.15	3.48	2.51	1.92	0.36	0.13	0.04	0.51	0.64	1.02	-1.81	-2.81	-0.17	-0.75	-0.66	-1.15	1.40	0.09	-2.29	4.00	0.88	-5.59	1.18	0.05	-2.2

…/…

ST 2	***Rel. cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-4.21	-1.78	-0.20	-11.4	-5.96	-3.50	0.03	0.01	0.00	0.00	0.01	0.02	2.74	5.59	11.05	0.19	1.80	0.93	-0.11	0.00	4.35	-2.07	0.01	6.23	0.00	0.00	0.0
	Rail	1.10	0.02	0.01	0.02	0.03	0.05	-0.18	-0.27	-0.49	-2.20	-1.03	-1.21	2.73	1.03	2.21	0.52	0.27	0.24	0.00	-0.27	0.95	0.08	-0.20	1.04	0.00	-1.00	0.9
	Water	1.95	1.30	0.13	6.63	3.30	1.83	0.34	0.53	0.97	4.00	1.85	1.99	-4.72	-4.71	-10.0	-1.15	-1.93	-1.21	0.07	0.53	-4.06	1.39	0.34	-4.74	0.00	5.31	-3.7
/km	**Road**	-1.18	-0.24	-0.07	-2.99	-1.54	-0.83	0.01	0.00	0.00	0.00	0.00	0.01	0.72	1.45	2.93	0.07	0.22	0.12	-0.04	0.00	1.15	-0.47	0.00	2.65	0.00	0.00	0.0
	Rail	0.47	0.01	0.00	0.00	0.01	0.01	-0.34	-0.47	-0.67	-1.98	-1.11	-1.16	1.89	1.08	2.01	0.66	0.44	0.37	0.00	-0.46	1.03	0.03	-0.21	1.18	0.00	-1.05	0.9
	Water	0.06	0.05	0.07	3.14	1.50	0.78	1.28	1.72	2.55	4.78	2.77	2.55	-4.21	-3.94	-7.68	-2.59	-1.70	-1.42	0.03	1.72	-3.64	0.07	0.72	-4.25	0.00	4.64	-3.0
ST 3	***Rel. cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-1.58	-1.17	-1.13	-0.36	-1.37	-1.17	0.04	0.03	0.00	0.00	0.27	0.16	0.40	0.09	0.12	0.03	0.32	0.34	-0.84	0.02	0.04	-1.32	0.03	0.10	0.00	0.00	0.0
	Rail	0.98	1.21	0.44	0.36	0.45	0.63	-1.48	-0.47	-0.03	-6.08	-3.72	-2.23	1.69	2.95	6.25	0.15	0.39	1.76	0.84	-0.36	0.12	1.63	-3.29	0.33	0.00	-0.72	1.9
	Water	4.77	2.16	2.80	0.61	3.00	2.15	1.88	0.46	0.03	6.12	2.91	1.69	-2.49	-3.10	-6.56	-0.26	-1.40	-3.72	1.54	0.37	-0.25	2.28	3.31	-0.53	0.00	0.77	-1.7
/km	**Road**	-1.00	-0.87	-0.57	-0.21	-0.85	-0.69	0.03	0.02	0.00	0.00	0.30	0.17	0.28	0.05	0.07	0.02	0.16	0.18	-0.61	0.01	0.02	-1.77	0.04	0.10	0.00	0.00	0.0
	Rail	0.46	0.59	0.14	0.10	0.12	0.19	-2.32	-0.28	-0.04	-3.29	-2.18	-1.50	1.17	2.03	3.45	0.21	0.25	2.58	0.44	-0.23	0.12	1.09	-2.52	0.17	0.00	-0.43	1.4
	Water	1.28	0.79	0.65	0.22	1.15	0.79	7.32	0.44	0.05	3.85	2.20	1.64	-1.91	-2.67	-4.11	-0.56	-0.75	-9.09	0.45	0.38	-0.20	1.80	4.41	-0.39	0.00	0.53	-1.7
ST 4	***Rel. cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.56	-0.46	-0.56	-9.64	-4.22	-3.68	1.80	3.60	0.16	0.06	0.03	0.13	0.07	0.11	0.27	0.08	0.05	0.11	-0.22	0.07	0.10	-2.14	2.04	0.12	0.00	0.00	0.0
	Rail	0.11	0.13	0.23	4.16	1.79	1.43	-0.87	-1.66	-0.10	-0.09	-1.99	-3.19	4.51	5.72	0.13	0.02	0.09	0.16	0.09	-0.08	1.58	0.96	-0.90	3.99	0.00	-0.24	0.1
	Water	0.58	0.33	0.19	0.43	0.24	0.16	0.22	0.17	0.08	0.18	5.15	6.03	-7.17	-11.2	-0.84	-0.21	-0.36	-0.71	0.08	0.16	-4.36	0.38	0.10	-9.61	0.00	0.39	-0.2
/km	**Road**	-0.46	-0.32	-0.36	-6.95	-3.01	-2.45	1.31	2.63	0.10	0.06	0.02	0.08	0.03	0.05	0.11	0.07	0.04	0.09	-0.15	0.04	0.04	-1.91	1.71	0.06	0.00	0.00	0.0
	Rail	0.04	0.04	0.05	1.73	0.75	0.59	-0.46	-0.75	-0.08	-0.05	-2.88	-3.00	3.45	5.50	0.14	0.05	0.12	0.22	0.02	-0.09	2.49	0.53	-0.40	3.39	0.00	-0.18	0.1
	Water	0.14	0.07	0.05	0.06	0.04	0.03	0.38	0.26	0.15	0.11	7.92	5.56	-5.51	-10.3	-0.20	-0.18	-0.43	-0.72	0.02	0.23	-7.28	0.11	0.14	-6.14	0.00	0.39	-0.2
ST5		*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-2.01	-2.13	-2.51	-3.59	-2.25	-1.74	0.74	1.23	2.66	1.54	0.94	0.66	0.40	0.32	0.13	0.11	0.10	0.14	-1.81	1.08	0.08	-1.34	1.81	0.32	-4.32	0.24	0.2
	Rail	4.23	3.72	4.57	5.31	2.68	1.89	-2.15	-3.32	-7.25	-5.37	-3.46	-3.12	1.69	1.81	2.07	2.92	1.41	1.09	3.10	-3.03	1.44	5.86	-9.48	3.12	1.69	-0.61	1.3
	Water	3.26	3.41	1.50	3.11	4.03	3.16	6.31	7.33	15.12	8.70	5.32	4.81	-6.43	-7.88	-8.84	-15.8	-8.43	-8.51	2.77	6.84	-5.58	5.02	8.96	-7.60	0.76	4.65	-8.3
/km	**Road**	-2.65	-3.12	-3.27	-3.96	-2.38	-1.82	0.88	1.38	2.89	2.30	1.25	0.99	0.29	0.22	0.13	0.07	0.10	0.15	-2.69	1.20	0.10	-2.26	3.51	0.27	-2.90	0.15	0.1
	Rail	2.05	2.14	2.20	2.27	1.23	0.84	-1.05	-1.48	-2.90	-3.44	-2.20	-2.21	1.32	1.40	1.54	1.00	0.62	0.51	1.81	-1.33	1.29	8.08	-10.4	2.50	1.10	-0.43	1.3
	Water	1.82	2.10	0.63	1.91	1.68	1.52	4.23	4.45	7.16	11.04	7.29	6.46	-6.61	-8.38	-10.3	-6.90	-4.96	-4.95	1.72	4.05	-7.68	6.16	7.66	-6.47	0.72	3.33	-9.0

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ST 6	***Rel. cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.48	-0.46	-0.57	-0.37	-0.42	-0.45	0.04	0.08	0.12	0.01	0.06	0.05	0.02	-0.01	0.04	0.12	0.03	0.06	-0.32	0.08	-0.06	-0.52	0.03	-0.04	-0.06	0.00	0.0
	Rail	2.17	1.44	1.84	2.25	2.34	2.08	-1.39	-2.14	-2.87	-0.28	-0.97	-0.69	0.64	0.99	0.40	2.22	2.66	1.95	0.96	-1.66	0.93	3.79	-3.04	2.34	0.00	-0.01	0.1
	Water	1.81	1.82	2.19	0.84	1.02	1.16	0.45	0.62	0.71	0.09	0.09	0.06	-0.39	-0.37	-0.39	-1.65	-1.46	-1.36	1.27	0.39	-0.10	3.19	1.24	-0.59	0.01	0.00	-0.0
/km	**Road**	-1.07	-0.91	-1.17	-0.73	-0.77	-0.80	0.10	0.18	0.29	0.01	0.19	0.13	0.00	-0.09	0.07	0.22	-0.01	0.07	-0.65	0.17	-0.17	-1.23	0.07	-0.19	-0.03	0.00	-0.0
	Rail	0.93	0.60	0.86	0.79	0.76	0.73	-0.56	-0.80	-0.99	-0.09	-0.45	-0.33	0.30	0.51	0.15	0.72	1.06	0.81	0.43	-0.57	0.49	3.32	-2.57	2.04	0.00	-0.01	0.1
	Water	0.63	0.57	0.64	0.25	0.30	0.35	0.27	0.31	0.28	0.04	0.06	0.05	-0.16	-0.16	-0.15	-0.71	-0.70	-0.63	0.40	0.17	-0.07	1.97	1.53	-0.42	0.01	0.00	-0.0
ST 7	***Rel. Cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.97	-1.50	-0.30	-0.82	-1.10	-0.95	0.24	0.00	0.00	0.00	0.00	0.00	0.20	0.33	0.45	0.06	0.16	0.66	-0.20	0.00	0.18	-1.49	0.00	0.34	-0.70	0.00	0.0
	Rail	0.53	0.37	0.00	0.00	1.98	1.46	-1.91	-0.21	-0.31	-0.19	-0.13	-0.28	0.35	0.26	0.20	0.42	0.43	1.56	0.13	-0.21	0.09	0.80	-0.51	0.54	0.00	-0.11	0.0
	Water	2.36	3.87	0.73	1.95	0.99	0.96	1.10	0.16	0.24	0.14	0.10	0.20	-0.72	-0.97	-1.22	-0.46	-0.73	-3.43	0.40	0.16	-0.49	6.61	0.22	-1.47	0.12	0.15	-0.0
/km	**Road**	-1.09	-1.33	-0.60	-0.49	-2.01	-1.42	0.64	0.00	0.00	0.00	0.00	0.01	0.13	0.22	0.28	0.05	0.31	0.57	-0.39	0.00	0.11	-1.48	0.00	0.28	-0.53	0.00	0.0
	Rail	0.27	0.12	0.00	0.00	1.00	0.65	-1.47	-0.09	-0.10	-0.09	-0.10	-0.19	0.24	0.14	0.09	0.15	0.32	1.33	0.05	-0.09	0.05	0.43	-0.35	0.31	0.00	-0.09	0.0
	Water	0.49	0.70	0.50	0.27	0.15	0.14	1.63	0.13	0.13	0.11	0.13	0.28	-0.44	-0.32	-0.30	-0.24	-0.69	-2.35	0.26	0.12	-0.14	2.34	0.33	-0.75	0.17	0.13	-0.1
ST 8	***Rel. Cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.75	-0.80	-0.86	-0.84	-0.86	-0.86	0.08	0.05	0.07	0.13	0.09	0.08	0.19	0.23	0.48	0.43	0.27	0.16	-0.58	0.04	0.09	-0.50	0.01	0.21	-1.63	0.16	0.2
	Rail	2.21	2.74	1.82	1.93	2.63	1.99	-1.60	-0.56	-0.81	-1.30	-0.82	-0.87	0.17	0.09	0.16	0.40	0.63	1.18	2.51	-0.51	0.09	6.00	-2.86	0.50	2.50	-0.36	0.0
	Water	6.73	5.30	6.36	5.23	4.21	4.14	1.25	0.19	0.25	0.22	0.10	0.15	-1.72	-2.11	-4.35	-4.58	-3.43	-3.32	3.06	0.17	-0.86	5.73	0.32	-2.32	4.67	0.00	-1.8
/km	**Road**	-1.12	-1.27	-0.90	-1.25	-1.32	-1.14	0.19	0.13	0.18	0.36	0.23	0.21	0.14	0.19	0.43	0.18	0.11	0.07	-0.92	0.12	0.14	-0.42	0.01	0.15	-1.77	0.21	0.2
	Rail	1.41	1.62	1.21	1.35	1.37	1.10	-0.49	-0.28	-0.38	-0.91	-0.54	-0.53	0.12	0.09	0.14	0.07	0.11	0.17	1.49	-0.25	0.09	5.42	-2.40	0.44	1.57	-0.25	0.0
	Water	3.54	3.12	1.36	3.41	3.27	2.67	0.44	0.09	0.14	0.61	0.25	0.32	-1.25	-1.56	-3.37	-0.97	-0.91	-0.90	1.01	0.09	-1.26	4.17	0.51	-1.91	2.88	0.00	-1.4
ST 9	***Rel. Cost***	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.90*	*0.95*	*0.98*	*1.02*	*1.05*	*1.10*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.95*	*0.9*
ons	**Road**	-0.13	-0.17	-0.28	-0.10	-0.16	-0.20	0.02	0.01	0.02	0.04	0.01	0.02	0.06	0.05	0.04	0.19	0.11	0.08	-0.15	0.01	0.04	-0.21	0.02	0.05	-0.10	0.00	0.0
	Rail	2.40	2.28	3.24	2.87	2.44	1.88	-1.34	-1.66	-1.31	-2.63	-1.83	-1.54	0.14	0.19	0.40	0.01	0.00	0.02	2.25	-1.59	0.19	0.53	-4.38	0.26	2.23	-1.77	0.2
	Water	12.04	19.33	26.82	6.86	8.72	8.39	0.47	0.37	0.13	4.83	2.29	1.44	-4.82	-5.07	-7.44	-19.7	-11.9	-10.6	16.66	0.05	-4.84	28.60	0.16	-3.70	5.47	1.32	-8.2
/km	**Road**	-1.18	-1.19	-1.69	-1.64	-1.65	-1.42	0.72	0.86	0.65	0.96	0.74	0.59	0.09	0.05	0.03	0.13	0.11	0.07	-1.16	0.84	0.04	-0.30	0.03	0.07	-1.56	1.28	0.0
	Rail	1.83	1.63	2.15	2.08	1.78	1.45	-0.95	-1.16	-0.93	-2.01	-1.44	-1.09	0.16	0.29	0.64	0.02	0.01	0.02	1.60	-1.12	0.29	0.16	-3.62	0.21	1.66	-1.21	0.3
	Water	4.21	7.06	13.27	3.30	8.52	7.00	1.16	0.78	0.71	20.70	9.26	5.04	-6.72	-10.0	-20.9	-7.67	-6.13	-5.04	6.50	0.28	-9.83	28.70	0.26	-3.45	2.86	1.05	-11.