



STUDIECENTRUM VOOR ECONOMISCH EN SOCIAAL ONDERZOEK

THE IMPACT OF PORT CHOICE ON INLAND
TRANSPORTATION

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A b s t r a c t

Every year the port authority of Antwerp (Belgium) receives public funds, among other things for dredging and deepening the maritime access routes and for the building and maintaining of locks. The Belgian government, however, intends a shift of its (scarce) investment credits towards other seaports, particularly Ghent and Zeebrugge. In the long run this policy change will undoubtedly influence the port choice and probably cause a traffic diversion at the expense of Antwerp. This will have a great influence on the structure of inland transportation, with important consequences concerning congestion, private investment, regional incomes ...

The impact of port choice on the inland transportation is the central theme of this paper. To that end a disaggregated model of the demand for freight transport (15 commodity groups, 16 regions) is constructed.

1. Introduction (*)

Together with Rotterdam the port of Antwerp occupies a dominant position among the ports of the Hamburg-Le Havre range and as thus also between the ports of the world. In 1982 the total traffic amounted to 84.2 million tons. It's no wonder that to a great extent the Belgian inland transportation is oriented towards the port of Antwerp.

Every year the port authority receives public funds, among other things for dredging and deepening the maritime access routes and for the building and maintaining of locks. The Belgian government, however, intends a shift of its (scarce) investment credits towards other seaports, particularly Ghent and Zeebrugge. In the long run this policy change will undoubtedly influence the port choice and probably cause a traffic diversion at the expense of Antwerp. This will have a great influence on the structure of inland transportation, with important consequences concerning congestion, private investment, regional incomes...

The impact of port choice on the inland transportation is the central theme of this paper. To that end a disaggregated model of the demand for freight transport (15 commodity groups, 16 regions) is constructed.

The paper is subdivided into three chapters. A first one concerns the Belgian national port policy, followed by a brief explanation of the used model in chapter two. The third chapter presents the results of a simulation exercise, with a prediction of the changed inland transportation pattern as a result of the shift in port choice. Thus we can investigate the consequences concerning modal shares, infrastructure and the cost of the shift in the inland transportation.

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2. The national port policy

The existence of a transportation infrastructure has a strong positive influence on the economic development of the country or a region. As a generating factor for economic activity seaports traditionally capture an important position. They are centres for delivery and handling of raw materials and finished products.

The various port authorities are aware of the activity generating character of a seaport. This explains to a great extent the effort to get as large a share as possible of the investment funds. In Belgium, investments on behalf of ports and their maritime access routes are initiated by two agents (Suykens, 1983, p. 82). On the one hand there are initiatives by the national government which itself carries out some infrastructural works. On the other hand there are initiatives of the port administrators. They undertake the investments under their own control, but they can ask for subsidies from the national government. According to the type of investment these subsidies amount to 60 % or 100 % of the project.

During the last few years there has been a lot of controversy around the national port policy. The decisions by the Belgian government to build a breakwater with a length of 1750 metres in the outport of Zeebrugge and the intention of adding a deep sea water quay too, has aggravated the opposition from the other seaports (Antwerp and Ghent). They fear that these additions in Zeebrugge will absorb the lion's share of the available budgetary credits and ultimately of the trade.

Table 1 gives an overall picture of the realized investment credits in the period 1979-83.

Table 1: Investment credits (x 10⁶ Belgian francs) (*)

budget item	1979	1980	1981	1982	1983
maritime access routes	590.4	905.0	1,280.0	2,048.7	1,459.0
government investments					
- Antwerp	1,729.8	1,986.0	2,187.9	2,361.5	2,919.9
- Ghent	31.1	129.1	273.3	239.5	258.7
- Zeebrugge	8,471.5	7,043.9	8,912.6	9,951.7	8,362.7
- other	214.2	643.5	140.1	230.2	96.8
subsidies	1,701.3	1,444.3	1,667.9	1,382.5	1,316.5
outside the budget	1,000.0	854.0	850.0	1,035.0	1,095.0
total	13,738.3	13,005.8	15,311.8	17,249.1	15,508.6

Source: Ministry of Public Works

In 1981 77.4 % of the government investments went to Zeebrugge, only 19.0 % to Antwerp.

Thus far a very important item in the discussion about the Belgian port problems has been neglected. What are the effects on the inland

(*) 1 U.S. \$ = 52.5 Belgian francs (20/11/1985)

freight transportation system of a changed port choice for the maritime import and export? Effects can be expected in modal choice and in the need for new infrastructure.

To evaluate the effects on the inland freight transportation of a changed port choice a simulation exercise has been elaborated. To that end we constructed a model for the inland freight transportation in Belgium. In the next chapter the specification of this model will be briefly discussed (*).

3. A model for the inland freight transport in Belgium

To build a model of the demand for freight transport as a policy tool, is a complex matter. There are many factors which determine the demand for freight transport and the resulting transportation pattern: a very differentiated freight packet; the character of derived demand; the many possible transport modes; the internal structure of the various modes.

This necessitates the development of a number of sub-models which together try to explain the link between on the one hand the transport flows and on the other hand the demand and supply factors. The flow model estimates the transport flows between regions (15 Belgian + 1 "world" region) for 15 commodity groups. The modal choice model indicates the shares of the three modes (road, rail, inland navigation) in the transport flows. The traffic conversion model computes the corresponding number of traffic movements, both loaded and unloaded.

The great advantage of working with sub-models is that each can be used on its own to explain in detail some aspects of the transportation problem.

3.1. The flow model

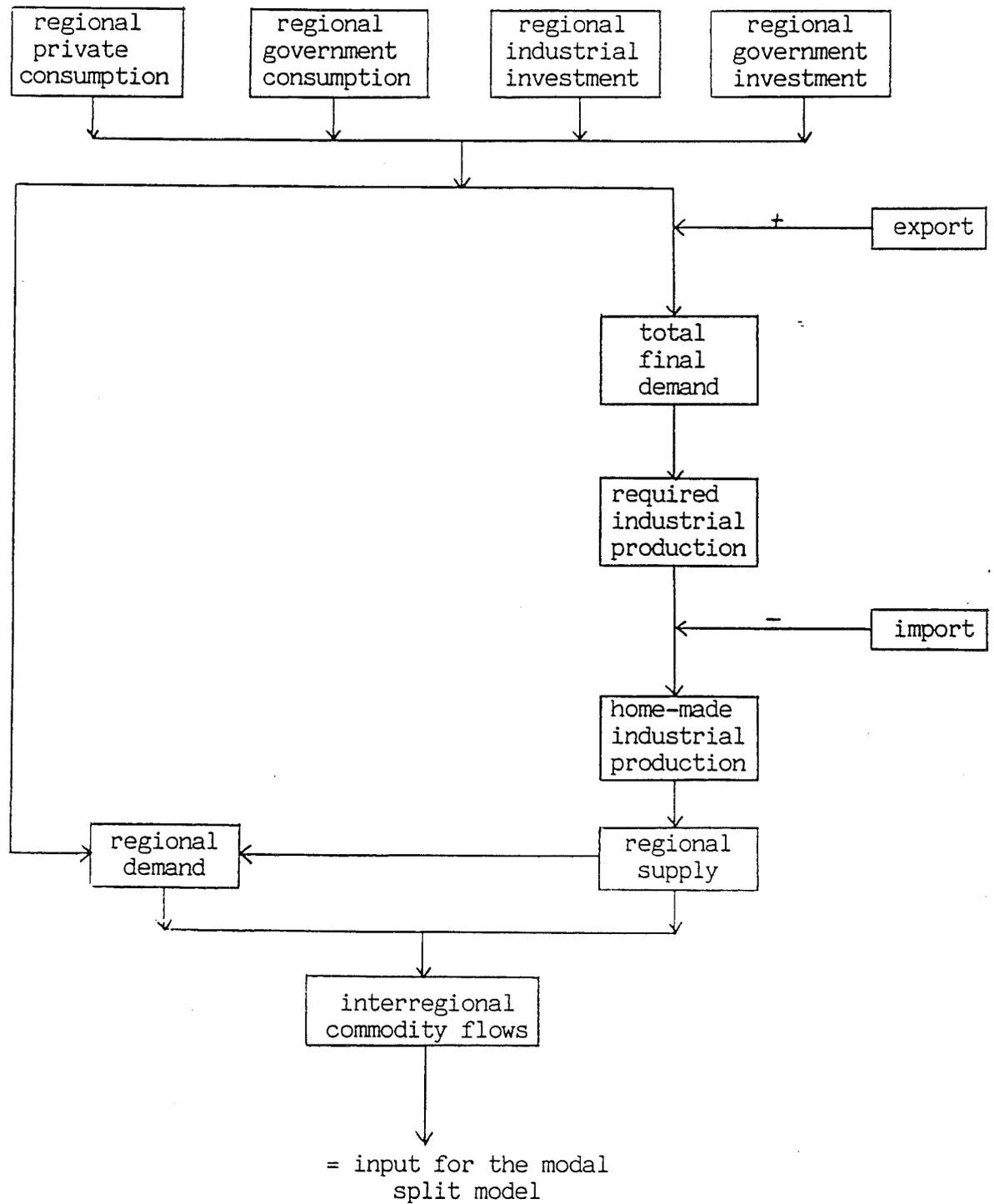
The flow model is based on the indirect relation between the volume and structure of the freight transportation and the level and structure of the economic activities. The model has to give a double output: on the one hand the total volume of transportation entering and leaving the 15 Belgian regions and the "foreign" region, on the other hand a division of these results into 15 commodity groups. Ultimately commodity flows can be predicted between regions for every commodity group.

The flow model is an integration of a production/attraction model and a distribution model. The generation of transport in a region depends on the kind and level of the economic activity in the region (supply side); the transportation attraction depends on the same factors as well as on more specific final demand factors (demand side). The distribution model forecasts the commodity flows between the regions.

Figure 1 gives the structure of the flow model. Total final demand can be seen as the sum of private consumption, demand for investment goods, government consumption, government investment and export. By

(*) The empirical estimation results are available on request.

Figure 1: Structure of the flow model



means of technical coefficients the industrial production needed to satisfy this final demand can be calculated. The result of subtracting the import is the Belgian industrial production. The home-made industrial production will be the input for the estimation of regional supply and indirectly of regional demand. In a last stage the interregional commodity flows are estimated.

The decision taker has direct or indirect control at the level of each of these sub-concepts of final demand. At each level he has policy options, for instance concerning the stimulation of private consumption or industrial investments, or concerning the level of import quotas. The flexible character of the model allows us to test the input of alternative economic policy options at each level.

The following section gives a survey of the model specification and an explanation of the symbols.

3.1.1. Survey of the model specification

a) Private consumption

$$\text{CON}(I,M) = [A(1 + \text{INFL})Y(M)_{t-1}]A\text{CON}(I) \quad [1]$$

b) Demand for investment goods

$$\text{VIG}(I,M) = \sum_J \{ \text{BCOEF}(I,J) \cdot \text{INV}(J,M) \} \quad [2]$$

c) Demand for final products

$$\begin{aligned} \text{TOTVR}(I) = \sum_M [& \text{CON}(I,M) + \text{VIG}(I,M) + \text{OVAN}(I,M) + \text{CONU}(I,M)] \\ & + \text{EXPI}(I) \end{aligned} \quad [3]$$

d) Industrial production

$$\text{PROD}(I) = \sum_J \text{INVER}(I,J) \cdot [\text{TOTVR}(J) - \text{IMP}(J)] \quad [4]$$

e) Regional supply

$$\text{RAAN}(I,M) = \text{PROD}(I) \cdot \text{STRAC}(I,M) \quad [5]$$

f) Regional demand

$$\begin{aligned} \text{RVRA}(I,M) = \text{CON}(I,M) + \text{VIG}(I,M) + \text{OVAN}(I,M) + \text{CONU}(I,M) + \\ (\sum_J \text{COEFF}(I,J) \cdot \text{RAAN}(I,M)) \end{aligned} \quad [6]$$

g) Introduction of the price variable

$$\text{RAT}(I,M) = \text{RAAN}(I,M) / \text{PRIJS}_1(I) \quad [7]$$

$$\text{RVT}(I,M) = \text{RVRA}(I,M) / \text{PRIJS}_2(I) \quad [8]$$

h) Regional commodity flows

Determine with the RAS-method for every commodity category I the matrix $A(M,N)$ in which $x(M,N) = z(M).y(M,N).s(N)$ [9]
 with: $\sum_M x(M,N) = RVT(N)$

$$\sum_N x(M,N) = RAT(M)$$

3.1.2. Explanation of the symbols

- $CON(I,M)$ = consumption of a commodity I in region M
 A = average propensity to consume
 $INFL$ = measure of the inflation, i.e. the increase of the index of consumption prices
 $Y(M)_{t-1}$ = delayed disposable income in region M, in current prices
 $ACON(I)$ = proportion of consumption expenditures for good I
 $VIG(I,M)$ = total investment demand for good I in region M
 $BCOEF(I,J)$ = exogenous technical capital coefficients: amount of good I required for one unit of investment by industry J
 $INV(J,M)$ = amount of investment expenditures by sector J in region M
 $TOTVR(I)$ = total final demand for good I
 $OVAN(I,M)$ = government consumption (good I, region M)
 $CONU(I,M)$ = government investments (good I, region M)
 $EXPI(I)$ = export of good I
 $PROD(I)$ = total production by industry I
 $COEFF(I,J)$ = matrix of technical coefficients: amount of good I required to produce one unit of good J
 $IMP(I)$ = import of good I
 $EENH(I,J)$ = the identity matrix
 $INVER(I,J)$ = inverse matrix of $EENH(I,J) - COEFF(I,J)$
 $RAAN(I,M)$ = regional output of industry I in region M
 $STRAC(I,M)$ = economic structure matrix
 $RVRA(I,M)$ = regional demand for good I in region M
 $RAT(I,M)$ = regional supply of industry I in region M (in tons)
 $RVT(I,M)$ = regional demand for good I in region M (in tons)
 $PRIJS_1(I)$ }
 $PRIJS_2(I)$ } = the average price per ton for good I, for regional demand and regional supply respectively
 $A(M,N,I)$ = matrix of predicted flows $x(M,N)$, for good I
 $x(M,N,I)$ = the predicted commodity flow between region M and region N, for good I
 $B(M,N,I)$ = matrix of observed commodity flows, for good I
 $y(M,N,I)$ = the observed commodity flow between region M and region N, for good I

$z(M), s(N)$ = correction coefficients

3.2. The modal split

The output of the flow model consists of disaggregated commodity flows from one region to another, for every commodity category. In the modal split model these commodity flows will be divided among the transportation modes. This allows us to predict the share of the various modes under different market circumstances.

In some cases the nature of the commodities can already determine the choice of transportation mode. For that reason this study works with homogeneous commodity groups. On the other hand a distinction has to be made between various competitive market situations. To that end all transportation links are grouped in various categories according to the observed competition between available transportation modes. For every commodity class a number of sub-models are distinguished:

- 3 transportation modes (road, rail, inland navigation)
- 2 transportation modes (road, inland navigation)
- 2 transportation modes (road, rail)

Finally for some links and some commodity groups there is a so-called "one mode situation", for instance because of the unavailability of the necessary infrastructure.

The model can be specified as follows:

a) three modes

$$\frac{SCH_{ij}}{WEG_{ij}} = C_1 \left[\frac{PSCH_{ij}}{PWE_{ij}} \right]^{\alpha_1} \cdot \left[\frac{PSPO_{ij}}{PWE_{ij}} \right]^{\beta_1} \cdot TON_{ij}^{\gamma_1} \cdot AFST_{ij}^{\delta_1} \cdot e^{\eta_1 \cdot DUM} \quad [10]$$

$$\frac{SPO_{ij}}{WEG_{ij}} = C_2 \left[\frac{PSCH_{ij}}{PWE_{ij}} \right]^{\alpha_2} \cdot \left[\frac{PSPO_{ij}}{PWE_{ij}} \right]^{\beta_2} \cdot TON_{ij}^{\gamma_2} \cdot AFST_{ij}^{\delta_2} \cdot e^{\eta_2 \cdot DUM} \quad [11]$$

$$\left[1 + \frac{SCH_{ij}}{WEG_{ij}} + \frac{SPO_{ij}}{WEG_{ij}} \right]^{-1} = WEG_{ij} \quad [12]$$

b) two modes: inland navigation - road transport

$$\frac{SCH_{ij}}{WEG_{ij}} = C_3 \left[\frac{PSCH_{ij}}{PWE_{ij}} \right]^{\alpha_3} \cdot TON_{ij}^{\gamma_3} \cdot AFST_{ij}^{\delta_3} \cdot e^{\eta_3 \cdot DUM} \quad [13]$$

$$\left[1 + \frac{SCH_{ij}}{WEG_{ij}} \right]^{-1} = WEG_{ij} \quad [14]$$

c) two modes: rail transport - road transport

$$\frac{SPO}{WEG}_{ij} = C_4 \left[\frac{PSPO}{PWEG}_{ij} \right]^{\alpha_4} \cdot TON_{ij}^{\gamma_4} \cdot AFST_{ij}^{\delta_4} \cdot e^{\eta_4 \cdot DUM} \quad [15]$$

$$\left[1 + \frac{SPO}{WEG}_{ij} \right]^{-1} = WEG_{ij} \quad [16]$$

- with: SCH_{ij} = share of the inland navigation sector in the total transportation from region i to region j
- SPO_{ij} = share of the railway company in the total transportation from region i to region j
- WEG_{ij} = share of the road transportation sector in the total transportation from region i to region j
- TON_{ij} = total amount transported from region i to region j
- $AFST_{ij}$ = distance (km) between regions i and j
- $PSCH_{ij}$ = price per ton for inland navigation transport on the link i→j
- $PSPO_{ij}$ = price per ton for rail transport on the link between regions i and j
- $PWEG_{ij}$ = price per ton for road transport on the link i→j
- DUM = dummy variable that has to take into account the possible different effect of transportation that crosses the frontier
- {- $DUM = 1$ for transportation that crosses the border
 - {- $DUM = 0$ for inland transportation

The model specification can be justified as follows. The modal choice will unquestionably be influenced by the relative price level. The average distance per ton transported is smaller for road transportation than for inland navigation and especially for rail transport. This suggests that the distance factor can determine the modal choice. The coefficient really estimates part of the price effect that was not charged via the price variable. The variable TON has been included because the existence of a regular and sufficient great quantity to transport does not exclude typical bulk carriers such as the inland navigation and the railroad company. The dummy variable tests whether inland transportation and transportation that crosses the frontier have a significant effect on the choice of transportation mode.

3.3. Traffic conversion

Traffic conversion models convert transportation flows into traffic movements per mode, because the volume of traffic movements is needed for many questions in transportation economics. The flow and modal split models estimate the transportation flows for every mode expressed in tons. From these, the corresponding number of traffic movements must be calculated.

But there are serious problems (NVI, 1978, pp. 181-182). First of all it is not enough to make a calculation per mode of the number of

movements on each geographical link. It is necessary to subdivide the traffic movements into capacity classes. The use of the inland navigation infrastructure for instance will certainly be influenced by the type of barge used: a Rhine barge of 2,000 ton makes a higher use of the lock capacity than a small barge of 300 ton (a so-called "Spits"). Furthermore, the barge type determines what canals and rivers can be used for inland navigation transport between two regions, in other words the route choice depends upon the barge type used.

Secondly, there are the number of empty movements, a part of the total number of movements that cannot be neglected. The number of empty movements is a function of the unbalance in transportation flows between regions, but also a function of the existing exploitation organization.

Thirdly, the investigation of the traffic conversion has to cope with serious data problems. The available data imposed important limitations, among other things concerning the calculation of the empty movements. And fourthly every traffic conversion will be influenced by elements of both the demand and supply side.

Because of these problems traffic conversion involves two separate components. A first part concerns the conversion of the transport flows in ton towards loaded traffic movements per capacity class. A second part calculates for each capacity class the number of empty movements. This study is restricted to a working-method on the basis of simple hypotheses, for instance by assuming a constant character of the capacity-shares and the average shipments.

The working-method pursued can be illustrated for the inland navigation sector. In a first stage the various transportation links are subdivided into a number of categories on the basis of admitted barge types. Subsequently for every barge type the average share in total transportation (per commodity class and per competitive category) is calculated. These shares are then used to calculate total tonnage-to-transport for each barge type.

Data also exists to calculate the average shipment per commodity class and per barge type for every capacity class. In the short and medium term the variations in these average shipments are assumed to be low because for most barge types the average loading coefficient is already high and the maximum admitted capacity gives the upper-limit.

Next the number of loaded traffic movements can be calculated by dividing the calculated tonnages to transport by the average shipment. To get the number of movements per barge type on a relation $i \rightarrow j$ one has to make a summation along the various commodity classes.

The number of empty movements is considered as a function of the number of loaded movements in the opposite direction. For every capacity class we estimate the following regression:

$$\ln L_{ij} = \alpha + \beta \ln B_{ji} + \gamma \ln AFST_{ij} \quad [17]$$

with: L_{ij} = total number of empty movements per capacity class on the relation $i \rightarrow j$

B_{ji} = total number of loaded movements per capacity class in the opposite direction $j \rightarrow i$

$AFST_{ij}$ = distance between region i and region j
 α, β, γ = elasticities to estimate

For every region the number of entering and leaving barges has to be equal. As a check we examine the following equation:

$$\sum_i [B_{ij} + L_{ij}] = \sum_i [B_{ji} + L_{ji}] \quad [18]$$

The calibration of equation [18] can be done by varying L_{ij} or L_{ji} downwards.

4. Simulation: The effect of a changed port choice on the inland freight transportation

In this chapter we apply the model specified above to analyse the effects of a changed seaport choice on the inland freight transport.

We start this simulation exercise from the hypothesis that the government changes its national port policy considerably, by a shift of government investments towards Zeebrugge and by a strong regulation. We assume that the consequence of this government policy is that part of the maritime import and export shifts from the port of Antwerp to the port of Zeebrugge. And we assume that this happens without a relocalisation of the industrial places of business.

The only purpose of this simulation exercise is to analyse the possible consequences on the inland transportation system of this hypothetical new national seaport policy. While interpreting the simulation results the conditional context of the simulation exercise has to be taken into account.

In the first paragraph the government strategy will be discussed, with a detailed review of the changes that are assumed in the exogenous variables. Next the simulation results will be evaluated in the light of the used hypotheses. Since the model has been calibrated on data of 1981 the simulation exercise also has been carried out on the database of the same year.

4.1. Description of the strategy

The hypothetical government strategy used in this simulation exercise is that 2,098.8 million Belgian francs is diverted from Antwerp to Zeebrugge. This is the amount that the government invested in 1981 for the so-called "Antwerp left bank" (source: Ministry of Public Works). It is assumed that the government invests this amount instead on the port of Zeebrugge. There is no change in the other government investments (89.1 million Belgian francs) and subsidies (868.6 million Belgian francs) for the port of Antwerp. For the region Brugge-Zeebrugge part (30.7 %) of the diverted government investment goes to supplementary freight transportation, especially of building-materials. Another important part goes to staff expenditures. We accept however that, in view of the one-off character of such supplementary investment there will be no migration between regions.

Furthermore, we assume that the governmental port policy shifts half of the maritime import and export from Antwerp to Zeebrugge (*). No distinction is made between sorts of commodities (for instance general cargo - bulk cargo). Table 2 gives a review of the tonnages per commodity group that are shifted in this way. The shift concerns half the maritime import and export but does not influence the through-freight and the transportation of goods after bonded storage. It concerns less than 50 % of the total Antwerp port traffic.

Table 2: Assumed shift from Antwerp to Zeebrugge (tons)

commodity	loading (tons)	unloading (tons)
agriculture	857,829	383,589
alimentation	129,552	628,064
cattle-fodder	317,761	177,482
fuel	2,512,813	47,843
mineral oil	3,302,855	3,461,826
ores	1,985,174	16,999
metal	252,936	1,565,457
raw materials	281,312	828,646
fertilizer	706,765	703,633
chemical products	357,091	491,067
machines	97,183	174,440
metal ware	6,144	78,354
glass	2,410	43,512
leather	41,230	34,843
rest	232,769	382,994

Because of the shift in maritime traffic, we also assume that there is migration of skilled working-people (registered dockers) and so a shift in the regional allocation of disposable income. The migration and the reallocation of disposable income are calculated as follows. The assumed shift in working-people is limited to the dockers. In 1981 the daily average of the number of employed dockers amounted to 7,298 units (source: Central Council of the Trade and Industry). It can be assumed that the number of employed dockers decreases in accordance with the decreasing transportation volume. The volume shift is 28.38 % of the total volume of maritime traffic of the port of Antwerp (import, export, store in bond, through-freight). This means that 2,071 dockers will move from Antwerp to Zeebrugge. Multiplied by the average net income one gets a shift in disposable income of 775,175 million Belgian francs.

Finally it is also assumed that a shift in private investments takes place. Therefore use is made of the amount of investment expenditures per employed person in the industrial places of business. In total it concerns an amount of 488.9 million Belgian francs.

Implicitly it is assumed that no new traffic will be attracted. Since the shifts in the direction of Zeebrugge are always considered as coming from Antwerp, there is only an impact on the commodity flows between both regions and the remainder of the country (+ foreign countries considered as one supplementary region), together 60 links.

(*) There is only one exception: for the category "ores" one assumes a shift of 25 % in the discharges.

4.2. Simulation results

The main purpose of the simulation is to show the far-reaching consequences of this shift in traffic between (Belgian) seaports on the modal split and especially on the use of the inland infrastructure.

4.2.1. Effect on modal shares

Table 3 compares the modal shares in the global inland transportation as they actually were in the reference year (1981) and as they would have been in the Antwerp-Zeebrugge strategy.

Table 3: Modal shares

commodity	reference year (1981)			strategy Antwerp-Zeebrugge		
	road	inland navigation	rail	road	inland navigation	rail
agriculture	80.48	15.98	3.54	81.05	15.50	3.45
alimentation	95.74	2.66	1.60	95.92	2.46	1.62
cattle-fodder	71.91	25.98	2.11	73.07	24.87	2.06
fuel	27.78	23.69	48.53	29.38	19.49	51.13
mineral oil	35.96	54.69	9.35	34.84	56.99	8.17
ores	13.27	30.05	56.68	15.69	27.32	56.98
metal	43.94	25.06	31.00	45.43	22.29	32.28
raw materials	85.96	12.76	1.28	86.28	12.37	1.35
fertilizers	65.70	22.41	11.89	66.02	22.14	11.84
chemical products	69.69	24.43	5.88	70.23	23.97	5.80
machines	87.46	2.70	9.84	87.65	2.55	9.80
metal ware	98.18	0.37	1.45	98.19	0.35	1.46
glass	93.07	0.36	6.57	92.93	0.36	6.71
leather	97.93	0.03	2.04	97.95	0.03	2.02
rest	89.56	3.70	7.34	89.49	2.87	7.64
total	71.20	18.34	10.46	71.44	17.91	10.65

Globally, the inland navigation sector loses a part of its total market share (-2.3 %), mostly to the railroad company (+ 1.8 %) but also the road sector (+ 0.3 %). This trend applies to almost all commodity groups. The inland navigation sector can only increase its share in the mineral oil category. For the fuel category the share of the same inland navigation sector decreases by 17.7 %. With the exception of the shift between mineral oil and fuel the composition of the commodity package remains stable for all modes.

These shifts in modal shares do not seem very high. However, only a short term simulation is used, without great changes in the localisation of consumption and production centres, and only 60 of the 256 regional links are considered. Yet, even with this limited number of links (in this case the links with Antwerp and Zeebrugge) a shift between modes can be observed so that we have to consider the problems that could arise for the inland navigation sector.

4.2.2. Effect on the infrastructure

When the regions around the towns Veurne and Brugge are not considered it can be seen that the remaining inland navigation transportation from and towards Zeebrugge has to pass the canal Brugge-Ghent (cfr. figure 2). For the most important commodity groups of the inland navigation sector (fuel, mineral oil, ores, metal products, raw materials, fertilizers, chemical products) the total tonnage that has to pass the canal has been calculated. With the reference scenario the region of Brugge gets a total (entering + leaving) traffic of 1,571,527 tons, with the simulation exercise 7,081,990 tons, or a quadrupling of traffic. Important capacity problems arise.

Additionally there is the problem of the barge type that can be used. The port of Antwerp is connected with the main consumption and production centres (Brussels, Liege, Charleroi,...) with an inland navigation network that allows the use of barges of at least 1,350 tons. Zeebrugge doesn't have the same accessibility because of the bottleneck formed by the canal Brugge-Ghent. Now the canal between Brugge and Sint-Joris-ten-Distel allows the use of barges of maximum 600 tons, between Sint-Joris-ten-Distel and Lovendegem 1,350 tons, further until Ghent 2,000 tons. Over and above the capacity problem there is also the problem of the limitation of the maximum allowed barge type.

Infrastructure limitations can of course be met by additional investments, for instance in the further extension of the canal network. In this context it is easy to understand the request of the M.B.Z. (managing institution of the port of Zeebrugge) for the construction of the so-called "Northern canal", an alternative link between Ghent and the coast. However, this type of investment has to be added to the investment package of Zeebrugge because it means a valorization of the port potential of Zeebrugge.

4.2.3. Effect on the costs of the inland transportation

In another study (Van de Voorde, 1985) marginal costs have been calculated for various transportation modes. On the basis of these marginal costs and the above-mentioned simulation results an approximate cost calculation can be made of the effect on inland transportation cost.

The total tonnage to transport remains constant in the simulation, but there is a modal shift. Also the total number of ton-kilometres increases because of the longer distances between Zeebrugge and the hinterland and also because of some infrastructural limitations. The growth figures per mode are +3.02 % for the railroad company, -0.28 % for the inland navigation sector and + 0.54 % for the road transport sector.

The shifts in ton-kilometres multiplied by the marginal costs lead to the following cost shifts per mode: railway (+ 474.0 million Belgian francs), inland navigation (- 36.5 million Belgian francs), road transport (+101.9 million Belgian francs). The supplementary costs because of the simulated shifts in inland transportation amount to 539.4 million Belgian francs.

However, a calculation on the basis of marginal costs and calculated for the global transport system is only a first rough approximation

of the cost of this port strategy of the government. Further research should be based on disaggregated cost models. Then it will be possible to calculate in a detailed way per transportation link the exact cost of a modal shift, analysed per commodity group, way of transportation and capacity class.

5. Conclusion

This paper was concerned with the influence of port choice on inland freight transport. With a constructed inland traffic movement model the effects were simulated of a national port investment shift from Antwerp to Zeebrugge.

The port investment shift was assumed to divert half of the maritime import-export flow and consequently some skilled man-power and personal income from Antwerp to Zeebrugge. The resultant changes in the transportation modes was that the share of inland navigation traffic would decline, mostly in favor of the rail system. This effect could be observed for 14 of the 15 commodities, and globally. When also the shift in regional traffic flow was considered then some serious infrastructural bottlenecks appeared. Especially the canal Brugge-Ghent would not be able to handle the quadrupling of the traffic tonnage nor the need for 1,350 ton barge traffic between Zeebrugge and its hinterland. Additional investments on this waterway would be necessary to use an enlarged port of Zeebrugge optimally. A first approximation to the transportation cost effect showed that there could be a cost increase of 539 million Belgian francs a year, mostly as the effect of the decreased share of the relative cheaper navigational system, the lengthening of the average distance travelled and the barge-size limitation.

We conclude that the construction of disaggregated traffic movement models and their use in simulation of effects of policy shifts is a meaningful exercise as a tool for the evaluation of policy proposals in the transport sector.

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