THE STRATEGIC FLEMISH FREIGHT MODEL AT THE INTERSECTION OF POLICY ISSUES AND THE AVAILABLE DATA

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INTRODUCTION

The Flemish authorities use a strategic transport freight model to forecast the demand for freight transport in the future and to support the decision making process for large infrastructure investments. An important requirement is the ability of the model to forecast effects of policy measures affecting transportation costs and times of the modes.

These policy requirements on the one hand and the available data on the other hand put demands on the model (and the modeler) that may sometimes be hard to reconcile. In the case of the Flemish model, the input data comes from multiple sources with varying precision, vehicle-type information, commodity classifications and geographic aggregation levels. In this paper we discuss different strategies to combine and process the input data. This is important as it affects model outcomes. We evaluate them by presenting the direct effects and the impact on the model coefficients and elasticities. In addition we compare the methods used to the methods used in the aggregate-disaggregate-aggregate (ADA) freight models of Scandinavia and the Dutch BasGoed model.

The paper consists of three main parts. In the first part we outline applications for which earlier versions of the model have been used. After this we describe the model in general and give an overview of the available input data. In the second part we present the assumptions made during data preparation. Three selected examples are used to explain the effects of choices made by the modelers on the model outcomes. For each example we first describe the problem, explain possible solutions and discuss their impact on the results. In our analysis we focus on the mode and vehicle-type choice part of the model. These are estimated simultaneously and determine the sensitivity of the model to time and cost changes. In the last part we conclude and compare the model to other strategic freight models.

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1. PART – THE FLEMISH FREIGHT MODEL

Use of the model and resulting requirements

The strategic Flemish freight model is a static, aggregated multimodal transport model with Flanders (northern part of Belgium) as its study area. It takes into account the national and international flows of goods for road, rail and inland waterway (IWW) transports. To be able to make reliable predictions, it is not restricted to the developments in Flanders only, but takes into account trends of worldwide trading partners and European flows of goods that are shipped through Flanders.

The main use of the model is in making reliable long term predictions of the freight flows in Flanders. These predictions are used to evaluate infrastructure projects and policy measures. In addition, the estimated truck matrix is input for the Flemish strategic passenger transport model for joined assignment together with cars. In recent years, the model has been redeveloped in several projects and been used in various studies. The following list gives an overview of some of the applications.

- Study of the implementation of a smart kilometer tax system for trucks on Belgian highways and determined regional roads. The effects of different pricing strategies have been evaluated. Based on the results, a kilometer tax for trucks above 3.5 ton has been introduced on April 1st 2016
- Strategic study of the E313 (highway between Liège and Antwerp). Due to an alarming increase of traffic jams and accidents, this highway had been regularly in the news. With an average share of 23% in the number of vehicles (up to 40% during specific periods of the day), freight transport contributes massively to the problems. In the study the effects of different infrastructure improvements for alternative freight transport modes have been analyzed (Verkeerscentrum Vlaanderen, 2009).
- Study on capacities of locks between Bocholt and Herentals.
- Study of the need for a second rail-connection for the harbor of Antwerp.

To be able to perform these studies, it is necessary that the model distinguishes between different vehicle types and allows for trading between the available alternatives. This distinction is necessary in all modes to be able to study for instance road charges or deepening of IWW channels. A fine zoning within Flanders is required to study the impact of infrastructure projects on regional scale. At the same time, the purpose of the model allows larger zones outside the study region. Furthermore the data should be segmented in different commodities to be able to make accurate predictions on future developments taking into account changing markets.

Basic structure of the model

The current version (4.1.1) of the strategic Flemish freight model is a classical four-step traffic model with several additions such as a time-period choice model and the choice between direct transport and the use of logistic hubs by mode. The model starts with the application of production and attraction multipliers on socio-economic data (for future years these are forecasts themselves) for each zone. It uses 518 zones within Belgium and 96 external zones in Europe (see Figure 1). Given the productions and attractions per zone, the distribution is modeled by using a gravity model.

Figure 1: Overview of the zones of the Flemish freight model in two zoom levels.

Mode choice and vehicle-type choice are integrated in one nested-logit model and are estimated simultaneously. The model considers three road vehicle types, three train types and twelve IWW vessel types. The latter is split in two branches, namely direct and intermodal transport modes. For rail and the two IWW branches, substitution between specific alternatives is taken into account by estimating nesting coefficients (where possible). Figure 2 gives a schematic overview of the mode and vehicle-type (MV) choice model. Air transport and short sea shipping are not modeled. The attraction and production of the zones hosting harbors or airports enter the model as external input.

Whether transports are likely to be direct or go via a logistic hub is determined in a logistics module that follows the MV model. This is also where empty trips are included. The first round of network assignment is performed for the whole day. This is followed by a time-of-day choice model. In the final step, the traffic is assigned to the networks for 9 time periods separately.

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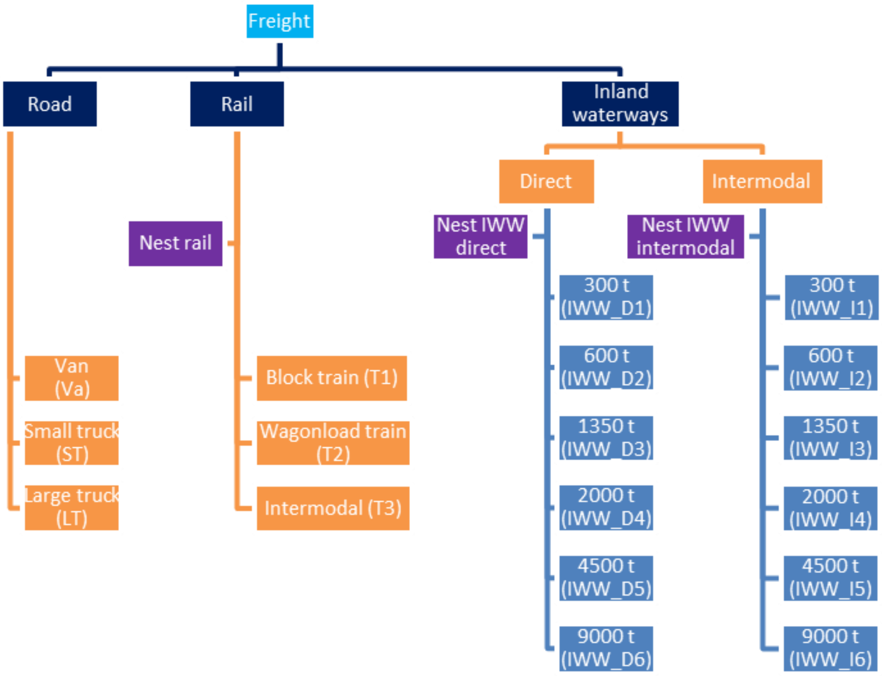
Figure 2: Schematic overview of the mode and vehicle-type choice (MV) model.



There are three separate network assignments: for IWW, rail transport and road transport (the latter takes place simultaneously with the assignment of the cars in the strategic passenger transport model). Skimming the networks leads to distances and travel times per mode. For intermodal transport (rail – road and IWW – road) the travel times and travel distances are estimated for both modes separately. All zones are accessible by road transport, but not all zones can be reached by rail and IWW. The transport costs per vehicle type are calculated from these skims by applying cost functions. They include transport time dependent costs, transport distance dependent costs, toll fees, resting periods, as well as costs for loading, unloading and transshipment. The general formula is:

$$Costs = \tilde{\alpha} + \beta_1 \cdot t_1 + \gamma_1 \cdot d_1 + \tilde{\Delta} + \beta_2 \cdot t_2 + \gamma_2 \cdot d_2 + \epsilon .$$

- $\tilde{\alpha}$ is the sum of the loading costs α_1 in the origin zone and the unloading costs α_2 in the destination zone. We assume that loading and unloading costs are equal and only depend on the vehicle type. As time and distance costs scale linearly, threshold effects are also incorporated in the costs for loading and unloading.
- β_1 and γ_1 are the time and distance dependent costs for rail or IWW. They are multiplied with the transport time t_1 and transport distance d_1 of one of these modes. The times and distances are vehicle type dependent.

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- $\tilde{\Delta}$ are the transshipment costs for intermodal transports. The assumption is made that these costs have to be paid once if the origin or destination zone is a harbor and otherwise twice. This implies that non-harbor zones require pre- and post-carriage by road transport.
- β_2 and γ_2 are the time and distance dependent costs for road transport (either direct or serving as access to and egress from rail or IWW). They are multiplied with the transport time t_2 and transport distance d_2 of this mode. Road user charges ϵ can be added to the transport cost of the road shipment. The distances and times are vehicle type dependent.

For direct trips the equation simplifies:

$$Costs = 2 \cdot \alpha_{1,2} + \beta_{1,2} \cdot t_{1,2} + \gamma_{1,2} \cdot d_{1,2} + \epsilon.$$

Goods are distinguished in 20 product groups (NST2007-classes) following the classification system for transport statistics by the Economic Commission. During the model calculations the commodities are treated independently. In this way, different demands for the different product groups can be taken into account and different trends between them are incorporated. For a more detailed description of the model see Borremans et al. 2015 or Grebe et al. 2016.

Available data

In this section we describe the available data for the three modes and the method to combine the individual data sets. As the structure of the available data for rail and IWW is very similar, it is sufficient for this paper to describe one of them in detail. We have chosen (without specific reason) for the IWW data. Afterwards the road data is described.

Two authorities operate the IWW channels within Flanders “Waterwegen en Zeekanaal NV” and “Nv De Scheepvaart”. Both providers register ships at the locks and record for each vessel their origin, destination and additional information. However, not all IWW transports in Flanders pass a Flemish lock on their journey and are therefore absent in the data. Especially shipments between the port of Antwerp and the north are lacking. The coverage is increased to nearly 100% by adding data for the Netherlands from Rijkswaterstaat.

The data from “Waterwegen en Zeekanaal NV” contain the transports in the provinces of East-Flanders, West-Flanders and Flemish Brabant differentiated by commodity group (classification that can be linked to NST), type of ship, maximum capacity and port of origin and destination. The total volume is 30.2 million tons.

The data from “Nv De Scheepvaart” provide origin-destination and cargo information per ships for all IWW transport for the two other Flemish provinces, namely Antwerp and Limburg. Furthermore the data are disaggregated by commodity group (classification that can be linked to NST), type of ship and maximum capacity. Overall this database contains 38.6 million tons transported.

Every three years, Rijkswaterstaat gives order to compile a data set with all IWW transports in the Netherlands. This set contains all IWW transport with origin or destination in the Netherlands and all transit transport passing through the Netherlands. The data provides detailed information about the origin, destination, commodities, transported volumes, vessel-type and vessel capacity. The data set which has been processed is the one of 2011 as this is closest to the base year of the model (2010). Between these two years the amount of goods transported by IWWs in the Netherlands has stayed almost constant (346.9 million ton in 2010 and 345.5 million ton in 2011, source: Eurostat). We assume that also the origin-destination patterns have not changed1 to be able to use the data to supplement the sets from Belgium.

The base year matrices for the 6 IWW vehicle types (the split between direct and intermodal shipments will be discussed in part 2) split by NST-classes are comprised from the three sets. We correct for double counts of shipments that are registered in multiple sets.

For road transports a similar data set with segmentation on the vehicle types is unavailable. Two sources provide information on the overall road transport, the database of the Federal Public Service of Belgium and the Eurostat database from the European Statistical Office. By combining these sources and data from an earlier version of the freight model, an overall origin-destination (OD) road matrix on NUTS3 level within Belgium and on country level outside Belgium has been created per NST-class. These matrices are further disaggregated to the fine zoning level of the model based on employment statistics. The segmentation of the general road matrices to vehicle-type matrices is realized with a deterministic model. The effects of choices in the deterministic model on the overall results of the freight model are discussed in part 2 of this paper.

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[1] We have found no data to prove or disprove this assumption.

2. **PART – DATA PREPARATION METHODS AND THEIR EFFECTS**

We focus in this part of the paper on the MV model, which is a nested logit model. The statements we make hold for all types of discrete choice models based on utility-maximization. These models have in common that a utility function has to be defined and estimated for all available alternatives. The utility functions of a freight model should at least contain the transport costs, the transport times and alternative specific constants (ASC) per vehicle type. The ASCs take into account all unobserved benefits or drawbacks of the specific vehicle type with respect to a reference category. Hence, the utility functions have forms similar to

$$U_i = ASC_i + cc \cdot Costs_i + tc \cdot Time_i,$$

where cc is the cost coefficient and tc the time coefficient. The Costs include amongst others time dependent costs and the Time represents the cargo component (e.g. interest on the value of the goods in transit). Of course time or cost coefficients can be mode specific, additional terms can be estimated or alternative specifications for the costs or time can be formulated. In practice time and cost coefficients can often not be estimated simultaneously due to the high correlation between travel times and transport costs. Therefore, the utility function in this model has the following structure with D_i representing dummy variables:

$$U_i = ASC_i + cc \cdot \left(\frac{Costs_i}{TonTot} + f \cdot \frac{Costs_i}{TonTot}\right) + \sum D_i.$$

Transport times are valuated with $f = 10\%$ of the transport costs for non-containerized goods and $f = 20\%$ for containerized goods, which means that transport time is valuated as shadow costs of 10% or 20% respectively (Significance, et al., 2013). Note that the costs have an explicit time dependent component (see part 1).

Before the utility functions can be calculated, the transport costs and times have to be determined. In many cases this is not a straightforward procedure but requires choices of the modeler. This is the topic of the next section.

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Transport times and costs

The transport times are calculated by skimming the three networks of the model. Usually and also in this specific case, the distances between origins and destinations are known with good precision, though the realized speeds and additional times for loading, unloading, transshipment or rest periods are less known and may vary substantially dependent on the location or the vehicle type. For some of these aspects data are available, but the information is far from complete. For the majority of these aspects we had to make assumptions, which we have validated on the available data to obtain the travel times per vehicle type.

For the transport costs the challenge is even bigger. Required are the transport costs for the volumes per OD-pair given in tons. A fundamental choice is whether costs are rounded down on complete vehicles or not[2]. We explain the pros and cons of both attempts using an example. Let us assume three OD-pairs, with exactly the same distances and travel times. The total volume per year is 5 ton for pair A, 10 ton for pair B and 1600 ton for pair C. In the case of rounding the costs on complete vehicles, the transport costs for A and B are identical for transports with small trucks with a capacity of 12 ton, whereas they differ by a factor of 2 in case of costs proportional to the transported volumes. In addition, it has to be noted that in the first case, both pairs have to pay for a whole truck and in the second case only for 42% or respectively 83% of the whole truck[3]. For case C the rounding affects the costs only marginally. In the case of rounding on whole vehicles the costs have to be paid for 134 trucks and in the second case for 133.33 trucks. It is obvious that rounding affects mainly transport volumes that are around the order of magnitude of the vehicle capacity.

In the model large IWW ships with a capacity of 2000 ton are an alternative to the small trucks. In the rounding case, the costs for the whole ship have to be paid and in the other case only for the fraction of the capacity used. This would be 0.25% for OD-pair A and 0.5% for OD-pair B and 80% for pair C. Table 1 gives an overview of our example.

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[2] These are the two extreme scenarios. Of course also a combination of costs per ton and costs per vehicle is possible. All arguments still hold as the discussion would be about the shares of the components.

[3] The costs for the whole truck would have to be calculated differently in both alternatives.

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Table 1: Difference between not-rounding and rounding down transport costs on entire vehicles.

Method	OD–pair	Costs road	Costs IWW	Costs road / Costs IWW
Not rounding	A (5 ton)	$0.42 \cdot C_T$	$0.0025 \cdot C_S$	3.33
Not rounding	B (10 ton)	$0.83 \cdot C_T$	$0.005 \cdot C_S$	3.33
Not rounding	C (1600 ton)	$133.33 \cdot C_T$	$0.8 \cdot C_S$	3.33
Rounding	A (5 ton)	C'_T	C'_S	0.02
Rounding	B (10 ton)	C'_T	C'_S	0.02
Rounding	C (1600 ton)	$134 \cdot C'_T$	C'_S	2.68

Assuming that a whole ship is 50 times more expensive than the truck, we can compare the costs for road and IWW transport. It is obvious that it is impossible to include economies of scale in models where all cost components are proportional to the shipped volume. In the example, road transport is always a factor of 3.33 more expensive than the IWW transport. In the case of rounding down, road transport is much cheaper for the small volumes whereas the ship scores better for the large volume.

This simplified version does not take into account differences in loading costs, transportation times or other differences between road and IWW transports. However, it illustrates nicely the effect of one of the choices which has to be made during model specification. In the Flemish freight model all costs are rounded on whole vehicles for direct transport and on containers for intermodal shipments. With this choice the model incorporates economies of scale.

In reality, costs are negotiated between shippers, carriers and receivers and depend on many factors we cannot include in a strategic model. To get them correct on average, the assumptions on capacities and load factors are crucial. Wrong cost estimations lead to incorrect cost sensitivity of the model. In general, it can be stated that if the costs of the chosen alternatives are estimated too low in the model, the cost sensitivity will be too high and if the costs of the unchosen alternatives are too low, also the cost sensitivity of the model will be too low.

In the Flemish freight model, the average shares (in tons) of all shipments are 45% for road, 19% for rail and 36% for IWW. Thus an underestimation of the costs for road transport would result in too high overall cost sensitivity, whereas an overestimation of road costs would lead to overall too low cost sensitivity.

In this model we have validated the costs by analyzing the average load factors calculated by the model per vehicle type in the base year. In combination with the assumed capacities we have calculated the average costs per ton for all vehicle types in the model. These costs were compared with assumptions made in the cost functions, which themselves were based on data. The differences between the initial costs calculated by the model and the assumptions in the cost functions were corrected by slightly adjusting the capacity of each vehicle type. These calibrated costs are an important ingredient of the MV model.

Before the MV model can be estimated, the road data has to be split into different vehicle types as this information is not available in the data. The most important aspects of the modelers' choice in this method are outlined in the following section.

Vehicle-type choice for road transport

For road transport OD-matrices are determined for all commodity groups (NST2007 classification). These matrices contain the annual transport flows between zones. However, these volumes have to be translated to trips with different types of trucks. The policy makers from the Flemish ministry wish to distinguish vans (1.5 ton capacity), small trucks (12.5 ton capacity) and large trucks (27 ton capacity) to be able to study the effects of different policy measures for these vehicle types.

The distinction between the three road vehicle types is realized with a deterministic model. Based on the transport costs the cheapest vehicle is chosen for each OD-pair and NST-class. As mentioned in the previous section, the costs are calculated for the minimum number of entire vehicles necessary. Due to the structure of the cost functions, one van would be chosen for volumes up to 1.5 ton, one small truck for volumes between 1.5 and 12.5 ton and one or multiple large trucks for all larger volumes. If we would apply this to the road matrix, the share of large trucks would be above 99% (in ton kilometers). However, observed is a percentage of approximately 81%.

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The share can be calibrated by introducing a trip frequency. The OD-matrix contains the road flows of goods between zone pairs in the base year by commodity group. This corresponds to a trip frequency ω equal to 1 (one trip per year). Per NST-class there are many zone pairs where several shippers and receivers are situated. For most of them the trip frequency is in reality much higher than once per year. Both effects are arguments for a trip frequency above 1. Counteracting this is consolidation of shipments from different NST-classes or zones. This implies that the degree of spatial resolution is another ingredient that affects the trip frequency in the model. Therefore, a comparison with average trip frequencies realized by shippers would be nonsense. The trip frequency is merely a calibration parameter of the model. Its value is calibrated by running the deterministic model with different settings and calculating the amount of ton kilometers transported with the different vehicle types. In Table 2 three variants are compared in which the trip frequencies for national and international transports are varied. It turns out that the best results are obtained with 16.2 trips for national transports and 8.4 for international (INT) transports (variant B). After the calibration the determined and observed shares per vehicle type are in good agreement.

Table 2: Fraction of large trucks for different trip frequencies in the deterministic model.

Variant	A	B	C
ω Belgium	5.4	16.2	32.4
ω INT	2.8	8.4	16.8
% large trucks	91.1%	81.7%	73.4%

To study the effect of the trip frequency, we have estimated the three variants of the model with, apart from the assumed trip frequency, exactly the same specifications. Afterwards we have calculated the elasticities. Table 3 summarizes the cost elasticities for road and IWW transport. Two characteristics of the results are remarkable. First the small elasticities for road transport and second the trend that the model becomes less and less sensitive to cost changes with increasing trip frequency.

Table 3: Cost elasticities (ton kilometers) of NST-class 1 for different trip frequencies in the deterministic vehicle-type choice model for road transport. Direct elasticities are printed bold.

Variant	A	A	B	B	C	C
Variation	IWW costs	Road costs	IWW costs	Road costs	IWW costs	Road costs
Road elasticity	0.06	**-0.03**	0.05	**-0.01**	0.05	**0**
Rail elasticity	0.09	0.52	0.03	0.1	0.07	0.07
IWW elasticity	**-0.81**	0.27	**-0.73**	0.06	**-0.73**	0.02

Both effects are caused by the fact that we have increased the costs for road transport by introducing the trip frequency. By splitting the volume in several trips the load factors per vehicle drop and the costs per ton increase. As rail and IWW data are not manipulated, road transport has become relatively more expensive. In the model, this results in a low cost sensitivity, in this case a decreasing cost coefficient for road transport. The cost coefficient and the average costs per ton kilometer are shown in Table 4.

Table 4: Average costs in Euro per ton kilometer for the three road vehicle types. The average costs for the three rail alternatives are between 5 and 8 Cent per ton*km and for IWW between 4 and 13 Cent per ton*km. Rail and IWW costs are constant for all three variants. The last row displays the cost coefficients of the model estimations for road transport.

Variant	A	B	C
Van (€ / ton / km)	2.72	5.66	9.40
Small truck (€ / ton / km)	0.46	0.53	0.58
Large truck (€ / ton / km)	0.13	0.14	0.15
Cost coefficient road	-0.04274	-0.00948	-0.00350

This is an unwanted effect and shows how we have changed the sensitivity of the whole model by adjusting the road transport costs. We have fixed this by calibrating not only the load factors for the road but also for all other vehicle types in the model. The output of the mode choice model after the calibration is in agreement with the assumptions made in the cost functions and the data. For rail and IWW data we have determined the load factors and the average

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load per vehicle type from observations, but for road data this information is not available for Flanders4

Distribution of intermodal shipments

As described in part 1, no deterministic model is needed for IWW and rail transport. The input data already distinguish between the different vehicle types. Unfortunately, a different kind of information is lacking. For rail and IWW data, shipments are carried out as direct transports or as intermodal shipments via intermodal hubs. The intermodal chains are combinations of rail/IWW and road transports. However, in the data, the road part is missing. Therefore, the real origins and/or final destinations are unknown. As a consequence large amounts of goods start or end their journeys in zones with an intermodal terminal and not in zones where they are produced or used. Not correcting these destinations would lead to a wrong OD-matrix in the base year and would introduce biases in the predictions of the model. Especially in the growth model problems would occur, as it is driven by growth rates in the industrial sectors and employment statistics per sector at origin and destination zones.

To solve this, a correction needs to add the missing road parts to intermodal shipments. In the Flemish freight model this adjustment is performed in three steps:

- Distinction between intermodal and direct transports
- Identification of possible origins or final destinations of intermodal trips
- Distribution of intermodal shipments from the hubs to the final destinations.

In this section we focus on the third step, but start with a short description of the other two.

The distinction between direct and intermodal trips is based on simple criteria. Intermodal shipments have to start or end at an intermodal terminal and goods have to be transported in containers. In addition, we require for IWW-intermodal that the IWW part is between an intermodal terminal and one of the large harbors, as that is the service intermodal terminals in Belgium offer. These criteria cause an unambiguous distinction between direct and intermodal shipments5.

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[4] As reference published information for the Netherlands have been used for the calibration.

[5] Unfortunately, no data is available to validate the classification.

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If a trip is identified as intermodal, it starts or ends at an intermodal terminal. For easier reading we continue our explanation by only describing the situation in which the intermodal terminal is the destination in the IWW (or rail) data and the goal is to determine the final destination. As possible final destinations we considered all neighboring zones with distances up to 50 km for rail and up to 20 km for IWW. These distances are based on information given by operators of intermodal terminals in Flanders. For all candidate zones, probabilities are calculated as a function of the distance, the number of jobs in the zone in relevant employment classes and the direction from where the transport arrives at the intermodal terminal. Based on these criteria, up to 100 zones with a broad range in probabilities are considered as destinations. Given these probabilities, we discuss different methods to distribute the corresponding volumes. We start with methods we have rejected and end with the implemented approach.

The simplest possibility is to distribute the total volume over the neighboring zones proportional to the calculated probabilities. After applying this method, the estimated MV model has almost completely lost its cost sensitivity. What has happened? Figure 2 indicates that the model contains 7 intermodal vehicle types (one for rail and six for IWW). This implies that 7 intermodal matrices have been provided. Many cells are filled with volumes much smaller than the capacities of the used trains or ships. For the necessary specification of the costs, we have tested two variants: rounding down on whole ships/trains and rounding on containers. The first alternative has the problem of extremely low load factors and thus too high costs for intermodal transport compared to direct shipments. In the second alternative, the costs of the intermodal IWW alternatives one below the other are useless. Transports with volumes that would fit on the smallest intermodal vessel are observed on larger types (with higher total costs). In both situations expensive alternatives are often chosen in the model, resulting in a low cost sensitivity. The reason is caused by splitting the transport flows into small amounts per transport. To solve this issue, bucket rounding is often used.

In bucket rounding algorithms, transports of relations with small volumes are added to larger shipments. The algorithms are applied after distributing the volumes proportional to the probabilities. The observed load factors and average sizes of shipments can be reproduced by choosing appropriate bucket sizes. This leads to correct costs and thus good elasticities. The question arises which method has to be used to fill the buckets. We discuss two extreme choices “random” and “from small to large”.

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In “random bucket rounding” we start in the upper left corner of the OD-matrix. If the volume in a cell is smaller than the bucket size, it is set to zero and added to the next cell, until the volume has reached the bucket size. The calculated sum is the entry of that OD-pair in the new matrix. This method is applied row after row until the end of the matrix is reached. When applying this method in future years with changed freight volumes the buckets are filled at different OD-pairs. The consequence is that freight flows seem to have moved geographically, but these moves are simply due to a modeling step. These movements add a systematic error to all results in studies of policy makers.

These movements can be prevented by adding small volumes to buckets that contain already larger volumes in the base year. This method is more robust but the disadvantage is that future patterns depend largely on the assumptions made in the base year. As we could not reduce the impact of these assumptions to our own satisfaction, we have struck a new path.

Instead of distributing the volumes proportional to the probabilities, we allocate the final destination on the basis of random draws using the same probabilities. For this method two variants have been explored. In the first variant we allocate the volumes of whole ships/trains observed in the original data to the final destination. In the second variant the destinations of individual containers are determined randomly.

The distribution of whole vehicles has the advantage that observed load factors and costs are automatically correct. However, the question arises how to allocate changing volumes in future years. Repeating the random draw for all volumes or remembering the base year distribution are possible alternatives. The consequences would be randomly moving transport flows or “fixed” flows that are insensitive to policy measures, which is similar to the features of bucket rounding described above. In this context, it is important to consider that the number of ships that is distributed per terminal is rather small. Therefore, the final distribution does not resemble the calculated probability distribution. If this would be the case, the problem would be absent.

When individual containers (load of 13.5 ton) are distributed their number increases sufficiently to resemble the probability distribution. Hence, a method that provides correct results in the base year can also be applied to future years. For rail data this is immediately the case, when costs are rounded down to containers. For IWW the vehicle-type classification and the corresponding costs needed further investigation. The best results have been

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obtained by adding the observed intermodal shipments of all IWW vehicle types and distribute them all together. The information on the original vehicle type per shipment is rejected. In the next step the vehicle types per OD-pair are calculated deterministically. The ship that fits best the allocated volume is selected. This leads to a new distribution of intermodal IWW types. The distribution can be calibrated on the observed data with a simple load factor (see also deterministic model of road transport). The calibrated distribution is shown in Table 5.

Table 5: Comparison of the observed distribution with the generated distributions of vehicle types for intermodal IWW shipments.

IWW types	300 ton	600 ton	1350 ton	2000 ton	4500 ton	9000 ton
Observed	20%	23%	31%	15%	11%	1%
Draw for containers	26%	23%	30%	12%	9%	1%

The deviation between the observed and the modeled distribution is in the order of a few percent. This is a smaller systematic effect than the other methods would introduce into the model. Therefore, this method is used in the Flemish freight model.

3. PART – RESULTS AND COMPARISON

In the previous section we have presented several practical problems we faced during the redevelopment of the Flemish freight model. The challenge was to fulfill the requirements of policy makers given the available data. We have discussed the specification of the cost functions and described methods to assign vehicle types to road transport and the final destinations to intermodal shipments. Where possible, we have discussed alternatives and their impact on the results. In this last section we zoom out and compare the Flemish freight model to the Dutch BasGoed model and the Scandinavian ADA-model.

In BasGoed (de Jong et al., 2011) mode choice and vehicle-type choice are two successive steps. The BasGoed model is set up as a modular, transparent and flexible set of instruments for policy making in the area of freight transport. It follows a step-wise development process. The operational model is the first step in an incremental building process. The mode choice model (for the main mode between origin and destination: road, rail or IWW) has been estimated based on the available aggregate data without the need to make crucial assumptions that affect the results (the transport cost by mode are given as a fixed rate per ton, so economies of scale in transport are absent, except for the differences between the three modes). The elasticities presented in de Jong et al. (2011) were calculated immediately after mode choice. Currently, research projects are being undertaken to implement models for vehicle-type choice, and multimodal container flows.

Almost the opposite approach is followed in Scandinavia. In Sweden, Norway and Denmark, national freight transport models have been developed that follow the so-called aggregate-disaggregate-aggregate approach (ADA, de Jong and Ben-Akiva, 2007; Ben-Akiva and de Jong, 2013). In these models, aggregate models are used first to predict future production-consumption matrices. These are annual flows from the place of production to the place of consumption that can use multiple modes (called ‘transport chains’, e.g. road-rail-road). Then follows a model for the choice of shipment size and transport chain, also including the determination of vehicle-type and transshipment locations. This is a model at the level of individual shipments (disaggregate), that is based on minimizing the transport, inventory and order costs for the shipment. A key reason for modeling these ‘logistics’ choices at the disaggregate level is that a decision-maker for the aggregate zone-to-zone flows does not exist. Instead, each firm-to-firm flow is optimized separately. On the other hand in the real world there are carriers and logistics service providers that consolidate trips for multiple shippers/receivers. In the ADA model, this is handled by allowing consolidation of transports that use the same terminals (if this would be cheaper), after having done an initial optimization at the firm-to-firm level, and then iterating a few times. Trip frequencies or shipment sizes do not have to be assumed, but are modeled endogenously (optimized), and economies of scale in transport are taken into account. The final step of the model is the aggregate assignment of the OD-matrices derived from the disaggregate models to the networks by mode. A relatively simple ADA model for Flanders was developed for the Flanders Mobility Masterplan Study (de Jong et al., 2010).

The Flemish freight model is positioned in the middle between the “simple” BasGoed and the “detailed” ADA model. The model distinguishes three modes and different vehicle types. As both are estimated simultaneously the model is sensitive to policy measures per type. Due to limitations of the data, a complete data driven approach was not feasible. We have solved this dilemma by making the necessary assumptions as explicit as possible and analyzing their effects in detail. We are aware that this is only the second best

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solution. To really validate the assumption or to develop a completely data driven model, micro-data on the whole transport chains is indispensable.

In Table 6 the overall elasticities of the Flemish freight model are summarized and compared to other strategical freight models. The differences are due to differences in goods transport for the countries studied but maybe also due to different approaches and implicit or explicit assumptions of the modelers. In general the elasticities of the Flemish freight model are within the range of the presented models.

Table 6: Comparison of average cost elasticities (in ton*km) for different strategic freight models. In brackets ranges are displayed. For the Flemish freight model these are the values of the commodity groups with the second largest and second smallest values. The ones with the largest/smallest values are less meaningful due to very small or no market shares in single modes.

Model	Country	Road	Rail	IWW
Flemish freight model	Belgium	-0.136 (-0.03, -0.19)	-0.419 (-0.09, -0.99)	-0.182 (-0.05, -0.47)
NODUS model (RAND Europe, 2002)	Walloon, BE			-0.76
(Significance and CE Delft, 2010)	INT	-0.4 (-0.2, -1.2)		
(Significance and VTI, 2010)	INT		(-0.8, -1.6)	
BASGOED (de Jong et al., 2011)	NL	-0.274	-0.882	-0.258

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