An exploration of freight transport forecasts for The Netherlands with BasGoed

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Abstract
This paper discusses an analysis of the bandwidth of freight transport forecasts for The Netherlands with the strategic freight transport model 'BasGoed'. The strategic freight transport model Basgoed was developed over the past years as a basic model, satisfying the basic needs of policy making, based on proven knowledge and available transport data. Starting point for the analysis are the recent long term scenarios for the Netherlands of CPB Netherlands Bureau for Economic Policy Analysis and PBL Netherlands Environmental Assessment Agency (WLO scenarios: Future outlook on welfare, prosperity and the human environment). These scenarios describe two base cases: the High and Low scenario. Both scenarios include a consistent set of assumptions on economic development (domestic growth by industry sector and international trade), infrastructure development, fuel prices, and logistic efficiency. The bandwidth of freight forecasts is further explored in five distinctive sensitivity analyses: different development in fuel prices, energy markets, CO_2-pricing, dematerialization and modal shift in the port of Rotterdam.

1. INTRODUCTION
This paper discusses an analysis of the bandwidth of freight transport forecasts for The Netherlands with the strategic freight transport model 'BasGoed'. The forecasts describe the expected freight volumes by mode under the two macro-economic scenarios, while varying the assumptions for six distinctive scenario developments. The freight transport forecasts are analyzed as in input to the so-called 'National Market and Capacity Analyses' (NMCA) in which the Ministry of Transport creates an inventory of potential bottlenecks for freight and passenger transport infrastructure networks (Ministry of Infrastructure and the Environment, 2017a).

The strategic transport model Basgoed is used to explore the bandwidth of freight transport forecasts. In its design, Basgoed is strategic in nature and not all policy measures, local developments or logistic choice behavior can be simulated explicitly. Where required the forecasts are improved externally, in a post-processing procedure, to account for relevant developments that cannot be modelled within Basgoed. The paper presents the policy context, the BasGoed model structure, the main assumptions behind the national freight scenarios, and the assumptions and results of the sensitivity analyses.

2. POLICY CONTEXT

Once every four years, the Dutch Ministry of Transport analyses its transport infrastructures to create an inventory of potential bottlenecks for freight and passenger transport and for each transport infrastructure network (road, rail or inland waterways) in the long term (Ministry of Infrastructure and the Environment, 2017a). This is called the National Market and Capacity Analyses (NMCA) which is an important input for the negotiations in forming a new government cabinet coalition. In the NMCA the focus is on the future development of mobility and the future accessibility bottlenecks. Sustainability, safety and viability are not taken into account in the NMCA. These aspects will of course also be taken into account in the decision in translating the accessibility problems and solutions for the multi-year infrastructure investment programme (MIRT).

Where available, the modus operandi is to use transport models for a systematic, quantitative analysis. The strategic freight transport model Basgoed is one of the instruments used, and provides multimodal freight forecasts. These forecasts are used as quantitative inputs in sectoral studies that make a more in-depth (uni-modal) analysis of the rail-, inland waterways-, or the road networks. These sectoral analyses are much more detailed compared to a strategic study with a transport model and also include qualitative analyses on various aspects. The forecasts from Basgoed are a vital input to the detailed sectoral analyses, and thus sensitivity analyses are a useful method to test the impacts of scenario assumptions or bandwidth of freight transport forecasts.

3. BASGOED STRATEGIC FREIGHT TRANSPORT MODEL

The strategic freight transport model Basgoed was developed over the past years as a basic model, satisfying the basic needs of policy making, based on proven knowledge and available transport data (Tavasszy et al., 2010). The structure of the simple freight model is based on the four step freight modeling approach, which includes (see e.g. Ortúzar and Willumsen, 2011):

- freight generation: the yearly volumes (weight) of freight produced and consumed;
- distribution: the transport flows between these regions;
- modal split, resulting in the flows between regions by mode;
- traffic conversion and assignment, describing the number of vehicles on the network.

We discuss the outline of this overall approach first.

Basgoed uses the existing economic module of the SMILE+ model (Bovenkerk, 2005; Tavasszy et al, 1998) for the freight generation. This module is based on an input-output framework, and translates economic scenarios in regional freight production and attraction forecasts (domestic and import/export). The same geographic level of detail was kept in the model, i.e. 40 regions within the Netherlands (NUTS3) and 29 in the rest of the world. International trade tables not including the Netherlands as origin or destination are also produced by this model, however not using the same I/O framework but based on exogenous trade scenario.

The distribution and modal split models are developed for Basgoed (De Jong et al., 2011). The distribution model generates OD-commodity flows in tons, based on a double constrained gravity based model. The modal spit model predicts the market share of road, rail and inland waterway for each OD-pair, using a multinomial logit choice. The modal split model is fed by the underlying assignment models to provide measures of transport costs and times between regions. The specification of these modules was kept simple explicitly, as they were the main exponent of the move towards simplification of the Dutch freight model system.

Exogenous models are used for the assignment stages. The traffic conversion and assignment stage is covered by the existing assignment models for passenger transport (the National Model System owned by Rijkswaterstaat), rail (the Nemo model owned by ProRail, the Dutch railway infrastructure provider) and inland waterways (BIVAS, owned by Rijkswaterstaat). The commodity classification used is NSTR-level1 (10commodity groups).

As the assignment models have substantially more detailed zoning systems, baseline flow tables are matched at the aggregate (NUTS3) level. For prediction purposes, a growth factor method (pivot point analysis) is used. The model is run for a baseline and a future situation. Growth factors are derived for the O/D tables by mode, expressed in tons moved yearly. These growth factors are applied to the observed vehicle, ship- and train matrices that are input for the detailed assignment models; after this, assignment of new flows can be done.

4. SCENARIOS IN BASGOED

4.1 Long term transport scenario's

The following figure sketches the process of deriving forecast indicators with a strategic freight model to analyze scenario uncertainties. The scenario uncertainties are categorized in distinctive categories, such development of the world economy, or the development of industry sectors in the domestic economy, or logistical developments. The developments in these uncertainties are translated into input parameters to the analyses: where possible, Basgoed is used. Where developments are not included in the model, external analyses or post-processing can be used.

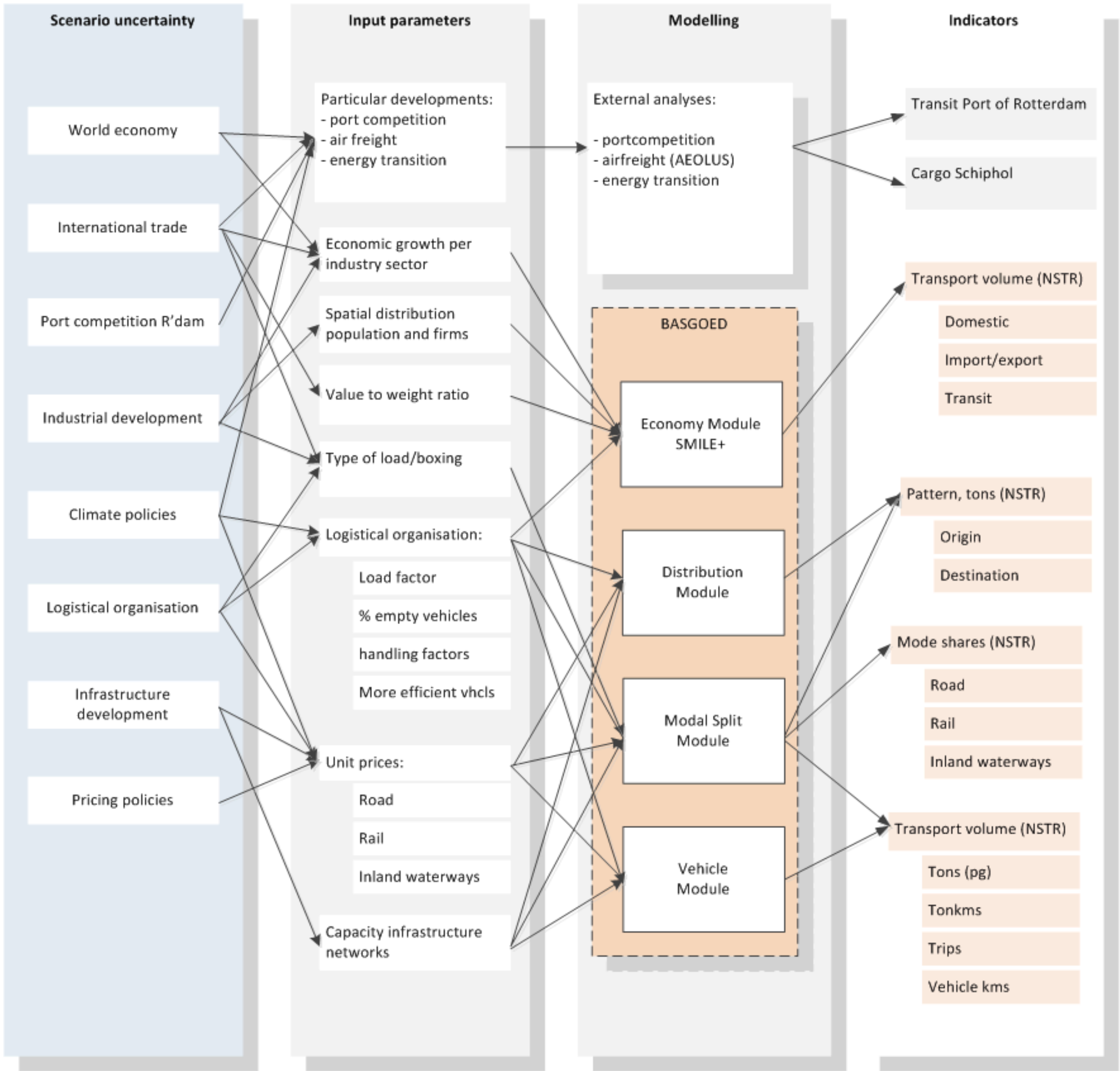

Figure 1: The position of Basgoed in the analysis of freight transport scenario uncertainties in WLO2. Source: Romijn et al. (2014).

Starting point for the analysis are the recent long term scenarios for the Netherlands, the WLO scenarios: Future outlook on welfare, prosperity and the human environment. These scenarios are formulated by the CPB Netherlands Bureau for Economic Policy Analysis and PBL Netherlands Environmental Assessment Agency. These scenarios describe two base cases: the High and Low scenario. For background information see: Romijn et al, 2016. Both scenarios include a consistent set of assumptions on economic development (domestic growth by industry sector and international trade), infrastructure development, fuel prices, and logistic efficiency. Table 1 provides a global overview of the main assumptions in the High and Low scenarios.

Table 1: Main scenario assumptions in the High and Low scenario in WLO2. Source: Romijn et al. (2014).

	High scenario:	**Low scenario:**
World economy	Strong growth	Slow growth
International trade	Strong growth	Slow growth
Strategic position Dutch deep sea ports	Remains constant	Remains constant
Industrial development	Large service sector	Small service sector
Climate policies	Substantial: reduction of coal and oil volumes	Moderate: no reduction of coal and oil volumes
European transport policy	Neutral trend	Neutral trend
Logistical organization	Widespread upscaling, consolidation and increasing efficiency	Minimal upscaling, consolidation and increasing efficiency
Dutch policy	Minimal differentiated	Minimal differentiated

4.2 Local developments

By means of post-processing, the BasGoed forecasts have been further improved by adding developments at local and national level, which cannot be predicted by BasGoed such as the closure of specific mines and power plants or the opening of planned large container terminals at specific locations. As BasGoed is a general strategic model at national level, these specific developments are not taken into account. As it may concern high volumes in tons or TEUs, the results of BasGoed had to be adapted.

Two types of developments have been distinguished. Developments that already took place between the base year 2014 and 2016, and developments that will be realized in the near future. More specific, these developments concern topics such as:

- Closure of sand and gravel pits in the southeast of the Netherlands (both -1.75 mln ton per annum)
- Opening of new sand pits in the province of Flevoland (+1.75 mln ton p.a.)
- Import of gravel from Belgium (+1.75 mln ton p.a.)
- Opening power plant Eemshaven (+1 mln ton coal p.a. shift from other power plants)
- Closure of power plants that use coal (-1.5 mln ton p.a. shift to other power plants)
- Opening bio mass power plant in Utrecht (+200.000 ton p.a.)
- Closure of paper plant in Nijmegen (-350.000 ton p.a.)
- Opening sugar terminal in Terneuzen (+240.000 ton p.a.)

- Shift of liquid manure in the province of Limburg (30.000 ton p.a.)
- Opening of new inland container terminals varying from 12.000 TEU – 500.000 TEU p.a.

All developments have consequences for the mode used. For example, the opening of container terminals led to splitting OD-relation in two legs. One by rail or inland waterways –to and from the port of Rotterdam- and the other by road. The closure of power plants leads to a reduction of coal by means of inland shipping.

Altogether, the changes have little impact on the total amount of transport in the future years (since most of these changes are no more than a shift from one location/mode to another). However, on a local and regional scale the impact might be big. As the BasGoed results are used in other models such as the Dutch National Model, the opening of new container terminals will cause a rerouting of road freight transport. On some routes this will cause less congestion, while near the container terminal the impacts become clearly visible.

The post-processing of the BasGoed results show that a general strategic freight model can, by definition, not be capable of catching all impacts. Implementation of specific big local developments improved the final results of BasGoed.

4.3 The high and low scenario forecast

The base forecast for the high and low scenarios, are based on the assumptions described in 4.1 and with the local developments described in 4.2. The global results of these base scenarios are given in Table 2 and figure 1. The global freight forecast indicator that is used, includes domestic, import, export and transit freight volume in tons.

Table 2: Ton per modality (in mln ton). Source: Ministry of Infrastructure and the Environment (2017b)

		Ton				Index 2014=100		
		2014	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
High	Road	939.6	1113.7	1227	1366.3	119	131	145
	Rail	41.4	61.1	77.8	98.7	148	188	238
	IWW	350.4	411.2	449.9	501.7	117	128	143
	Total	**1331.3**	**1586**	**1754.7**	**1966.8**	119	132	148
Low	Road	939.6	970.9	989.2	1013.6	103	105	108
	Rail	41.4	54.2	62.5	71.8	131	151	173
	IWW	350.4	379	394.5	422.4	108	113	121
	Total	**1331.3**	**1404.1**	**1446.2**	**1507.7**	105	109	113

The total volume of freight transport demand develops with a predicted growth index of 148 in the High scenario and 113 in the Low scenario between 2014 and 2050. This is around the prediction of the EU Reference Scenario which, measured in ton-kilometers, predicts a growth index of 134 for the Netherlands (European

Commission, 2016). Even though the definition of indicators differ, the scenarios have a similar order of magnitude.

Figure 2 shows the freight forecasts for the High and Low scenario, and the observed volumes between 1970 and 2014. The observed figures for road transport shows a large deviation in 2014: the base registration in this year includes a total of 200 million tonnes of road freight transport with Light Goods Vehicles (LGV = vans). For the other years from 1970 the amount of road freight with LGV's is not included which explains the steep rise of the road freight line in 2014. We included the structural break in the figure, since Basgoed uses 2014 as the base year. The figure also shows that the high scenario has a similar growth as recent decades, while the growth in the low scenario decreases to a lower rate. This is in line with the assumptions behind the scenarios. Sensitivity analyses of the main scenario assumptions showed that the economic scenario has the largest impact on the global scenario outcomes (Ruijs and de Bok, 2015).

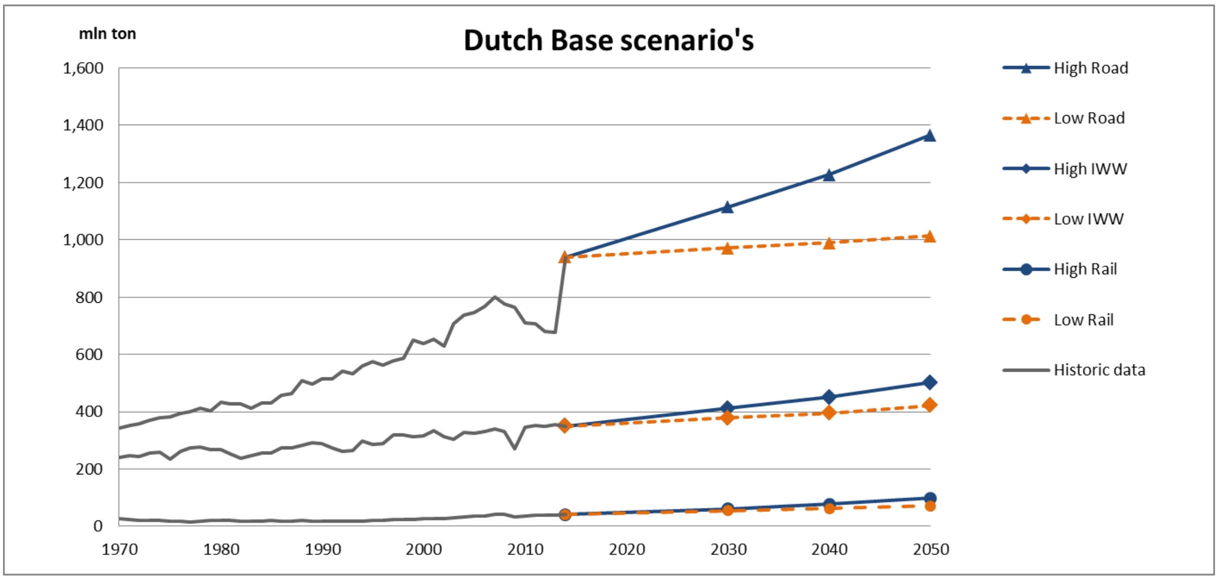

Figure 2: Freight forecasts in High and Low scenarios, in mln tons and by mode: 2014-2050, compared to observed volumes 1970-2014.

5. SENSITIVITY ANALYSES

To explore the bandwidth of freight forecasts, a number of assumptions for specific scenario developments or policy measures are varied. These include development in fuel price, energy transitions, CO_2-pricing, dematerialization, logistic efficiency and the implementation of an imposed modal shift policy in the port of Rotterdam. The sensitivity analyses are conducted for forecast year 2040, and depending on the analysis on the high and/or low scenario.

5.1 Fuel prices

The fuel price alternatives explore higher or lower fuel costs for road and inland waterways. The base scenario assumes a low fuel prices for the high scenario and high fuel prices in the low forecast scenario. In this sensitivity run the influence of these assumptions are tested. In the high scenario the fuel prices are increased and in the low scenario the fuel prices are decreased. The corresponding values are listed in Table 12.

The results of the fuel price scenarios are presented by transport mode in Table 3. The effects of changing the fuel prices are relative small. Fuel price only has an impact on the transport cost functions in the modal split models and the transport impedance in the Distribution module. The total amount of freight transport predicted by the Economy Module is not affected by the transport costs. Thus: fuel price mainly has an impact on modal shares, and a small influence on the OD pattern. The sensitivity runs show that with increasing energy costs for inland waterways and road the rail transport increases with 2% in the high scenario. The significantly lower fuel costs for road and IWW in the low scenario, leads to a decrease of rail transport of 5%.

Table 2: Assumed energy costs in Base scenario and Fuel price scenario

Energy cost	**Base scenario**		**Fuel price scenario**	
	High 2040	**Low 2040**	**High 2040**	**Low 2040**
cost (€/vhc/km)				
- road	0.21	0.3	0.23	0.21
- rail	6.92	6.92	6.92	6.92
- IWW	14.49	11.13	18.11	7.89

5.2 Energy transition

Energy carriers, in particular solids and oil, form an important share of the freight transport by rail and inland waterways. These transport flows may change drastically from a radical energy transition, but there is large uncertainty around such transitions. Influencing factors are (international) climate policies, technological developments and societal acceptance of new technologies such as carbon capture. The base scenarios assume an average trend in the energy sector without a major energy transition.

Two alternative scenarios for the energy markets are explored: a radical transition scenario towards renewables and a transition scenario to more coal. The first scenario assumes more energy production from local sources like solar and wind energy. By 2050, the import of energy carriers is strongly reduced, by 75%, in the high scenario, and more moderately in the low scenario, 16%. The second scenario assumes a larger role for solid mineral fuels and less oil / petroleum products based on the assumption of the overall availability of carbon capture and storage. The impact of both scenarios is also presented in Table 12. The results show that a drastic transition to renewable energy sources, such in the analysis for the High scenario, has a large impact on freight volumes, in particular for inland waterways (-20%) and rail transport (-16%).

Table 3: Impact of Fuel price- and Energy transition scenarios (in mln tons resp. % impact against base)

		Base scenario 2040	Fuel price scenario	Transition to renewables	Transition to more coal
High	Road	1227	0%	-2%	-1%
	Rail	77.8	2%	-16%	3%
	IWW	449.9	-1%	-20%	13%
	Total	**1754.7**	**0%**	**-6%**	**1%**
Low	Road	989.2	1%	0%	-1%
	Rail	62.5	-5%	-3%	4%
	IWW	394.5	-2%	-4%	22%
	Total	**1446.2**	**0%**	**-1%**	**1%**

5.3 CO_2-pricing inland waterway transport

One of the strong climate policy measures in the high scenario is an assumed strong (international) CO2-pricing policy that leads to a strong price increase for inland waterway transport. This measure is disputed, to say the least, and thus highly uncertain. The isolated effect of this policy measure is studied with a sensitivity runs for the high scenario, without the additional CO_2-pricing fee for inland waterway transport. It can be seen that not implementing a strong CO2-pricing fee for inland waterways leads to an increase of 4% of IWW transport in 2040 and 8% in 2050.

Table 4: Results sensitivity analysis emission fee CO2-pricing IWW (in mln tons resp. % impact against base)

		Base scenario				No CO_2-pricing IWW		
		2014	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
High	Road	939.6	1113.7	1227	1366.3	-1%	-1%	-2%
	Rail	41.4	61.1	77.8	98.7	-2%	-5%	-7%
	IWW	350.4	411.2	449.9	501.7	2%	4%	8%
	Total	**1331.3**	**1586**	**1754.7**	**1966.8**	0%	0%	0%

5.4 Dematerialization

Developments in value-weight ratio have a large impact on the magnitude of the freight flows. In the base scenarios it is taken into account that this value-weight ratio is expected to (continue to) increase in the future (dematerialization). This implies that for constant economic value, freight volume in tons decrease. The precise extent of dematerialization to be expected is an import uncertainty, however. This uncertainty is reason to investigate the consequences if actual dematerialization stays behind or exceeds the expectations. In the high scenario the value-weight ratio increases 0.5% annually, in the low scenario this ratio increases with 0.3% annually. In the sensitivity analyses the impact of these assumptions are investigated: in the Low scenario the value-weight ratio increase is doubled (0.6% annually) and in the high scenario the value weight ratio increase is reduced (halved to 0.25% annually).

The result of the alternative value-weight ratio development is presented in Table 5. The dematerialization assumptions have a large impact on the total freight transport: the high scenario forecast increases by 7%, and equally across all modes as can be expected because the value-weight ratio development is applied equally on all commodity types. The low scenario is 7% lower, assuming the stronger value-weight ratio development.

Table 5: Results sensitivity analyses dematerialization (in mln tons resp. % against base).

		Base 2040	Stronger Dematerialization	Weaker Dematerialization
High	Road	1227		7%
	Rail	77.8		7%
	IWW	449.9		7%
	Total	**1754.7**		**7%**
Low	Road	989.2	-7%	
	Rail	62.5	-7%	
	IWW	394.5	-7%	
	Total	**1446.2**	**-7%**	

5.6 Modal shift policy Maasvlakte

An important policy objective of the Dutch Ministry of Transport is to reduce road transport to and from the Port of Rotterdam to reduce traffic congestion on the highways in the Rijnmond region. One of the policies imposes a maximum road modal share of 35% for all hinterland transport to and from the Maasvlakte port basins in Rotterdam. This measure is implemented as one of the post-processing steps described in paragraph 4.2. By means of a sensitivity analysis the impacts of this policy assumption is studied by removing the modal share maximum from the post-processing analysis. The results are summarized in Table 6.

Table 6: Results sensitivity analysis Maasvlakte Modal Split policy in mln tons resp. % against base).

		Base scenario				No Modal shift		
		2014	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
High	Road	939.6	1113.7	1227	1366.3	0%	0%	0%
	Rail	41.4	61.1	77.8	98.7	2%	1%	1%
	IWW	350.4	411.2	449.9	501.7	1%	0%	0%
	Total	**1331.3**	**1586**	**1754.7**	**1966.8**	-	-	-
Low	Road	939.6	970.9	989.2	1013.6	0%	0%	0%
	Rail	41.4	54.2	62.5	71.8	2%	1%	0%
	IWW	350.4	379	394.5	422.4	1%	0%	0%
	Total	**1331.3**	**1404.1**	**1446.2**	**1507.7**	-	-	-

6. CONCLUSION

The paper presents the policy context, the main assumptions behind the national freight scenarios, the Basgoed model structure, and the assumptions and results of the sensitivity analyses.

The presented freight scenarios for the Netherlands provide a forecast for freight transport demand by mode, and for two distinctive scenarios. A particular aspect of the freight forecasts is the inclusion of adding local developments in a post-processing step to account for relevant developments that cannot be modelled within Basgoed. The bandwidth of the two scenarios can be labelled 'realistic' and certainly not extreme and the order of magnitude is comparable to the EU Reference scenario.

The presented sensitivity analyses in this paper serve as an exploration of impacts of specific measures in the scenarios. First of all this gives a systematic guestimate of the impact of particular developments. By discussing them collectively, more insight is provided in the level of importance of each scenario assumption. Sensitivity analyses prove valuable in providing insight in the robustness of the findings from the transport studies.

We emphasize that a strategic model like Basgoed has a limit to the possibilities to implement specific developments or logistic choice responses. The priority is to simulate top-down from global economic developments, through developments in infrastructure networks and transport costs, to vehicle specific forecasts, in a comprehensive and consistent manner.

In order to improve the BasGoed model to the responsiveness to specific logistic developments, the Dutch Ministry of Infrastructure and the Environment has laid out an improvement strategy in the long term road map for R&D of freight transport models (Tavasszy et al., 2010; Berg et al., 2015). Topics for improvement include the simulation of multimodal container transport (see De Bok et al, 2017), models for logistic behavior, or explicit modelling of deep sea port competition.

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REFERENCES

Berg, M. van den, L. Tavasszy, N. Groot, G. de Jong (2015) Meerjarenagenda Goederenvervoermodellen Rijkswaterstaat, paper presented at Vervoerslogistieke werkdagen 2015 [in Dutch].

Bovenkerk, M. (2005) SMILE + , the new and improved Dutch national freight model system, paper presented at the European Transport Conference 2005.

Bok, M. de, G. de Jong, L. Tavasszy, J. van Meijeren, I. Davydenko, M. Benjamins, N. Groot, O. Miete, M. van den Berg (2017) Development of a multimodal transport chain choice model for container transport for BasGoed, paper presented at the European Transport Conference 2017.

European Commission (2016) EU Reference Scenario 2016. Energy, transport and GHG emission Trends to 2050. (available at: http://ec.europa.eu/energy/en/data-analysis/energy-modelling, accessed September 6th, 2017)

Jong, G.C. de, Burgess, A., Tavasszy, L.,Versteegh, R., de Bok. M., & Schmorak, N. (2011) Distribution and modal split models for freight transport in The Netherlands, paper presented at the European Transport Conference 2011, Glasgow.

Ministry of Infrastructure and the Environment (2017a) Nationale Markt en Capaciteitsanalyse 2017, Hoofdrapport, may 2017, The Hague: Dutch Ministry of Infrastructure and the Environment. [in Dutch] (https://www.rijksoverheid.nl/documenten/rapporten/2017/05/01/nationale-markt-en-capaciteitsanalyse-2017-nmca)

Ministry of Infrastructure and the Environment (2017b) Gevoeligheidsanalyses Nationale Markt- en Capaciteitsanalyse, april 14th 2017, The Hague: Dutch Ministry of Infrastructure and the Environment. [in Dutch]

Ortúzar, J de Dios, L.G. Willumsen (2011) Modelling Transport, 4th Edition. Wiley Press.

Romijn, G, H. Hilbers, M. de Bok (2014) Lange termijn scenario's voor de ontwikkeling van het goederenvervoer in Nederland en de Nederlandse zeehavens, paper presented at the Vervoerslogistieke werkdagen 2014. [in Dutch]

Romijn, G., P. Verstraten, H. Hilbers & A. Brouwers (2016) Achtergronddocument Goederenvervoer en Zeehavens, WLO – Welvaart en Leefomgeving Scenariostudie voor 2030 en 2050. The Hague: CPB. [in Dutch] (http://www.wlo2015.nl/wp-content/uploads/pbl-2016-wlo-achtergronddocument-mobiliteit-goederenvervoer-en-zeehavens-1774.pdf)

Ruijs, K, M. de Bok (2015) Inzet Basis goederenvervoermodel (Basgoed) voor ontwikkeling van lange termijn scenario's van het goederenvervoer in Nederland (WLO2) , paper presented at the Vervoerslogistieke werkdagen 2014. [in Dutch]

Tavasszy, L, M Duijnisveld, F Hofman, S Pronk van Hoogeveen, J van der Waard, N Schmorak, M van de Berg, J Francke, M Martens, O van de Riet, H Poot, E Reiding (2010) Creating Transport Models That Matter: a Strategic View on Governance of Transport Models and Road Maps for Innovation. Paper presented at European Transport Conference 2010.

Tavasszy, L. A., B. Smeenk, C.J. Ruijgrok (1998). "A DSS For Modelling Logistic Chains in Freight Transport Policy Analysis." International Transactions in Operational Research 5(6): 447-459.