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Flitsch, Verena; Brümmerstedt, Katrin

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Freight Transport Modelling of Container Hinterland Supply Chains

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Freight Transport Modelling of Container Hinterland Supply Chains

Verena Flitsch and Katrin Brümmerstedt

Macroeconomic freight transport models serve as decision support for transport policy development. To evaluate infrastructure investments or policy measures these tools need to capture the underlying complexity of freight transport networks in a sufficient way. Recent developments in this field outline possibilities to combine aggregated and disaggregated approaches in freight transport modelling in order to integrate more realistic freight agent behaviour. In contrast to aggregated models, disaggregated approaches are able to simulate the decision behaviour on the micro-level of an individual decision maker.

In maritime container supply chains liner carriers or their brokers/agents and freight forwarders face a variety of interconnected logistical choices such as carrier, port, mode, route, shipment, or inventory choice. Modelling at least parts of these choices in disaggregated way could be of high value for adequate maritime hinterland policy development.

This paper provides both an overview of present freight transport models with and without a logistics step and applied methods to study maritime supply chain freight agents' behaviour. A summarizing framework for behavioural freight transport modelling in maritime container supply chains is introduced. Finally, the framework is applied to a container freight transport model under development.

Keywords: Freight Transport Modelling, Maritime Container Supply Chain, Choice Modelling

1 Introduction

Simulating present and forecasting future freight transport flows with macro-economic freight transport models serves as a strategic decision support for infrastructure investments or the evaluation of new policy measures. These models need to capture the underlying complexity of the examined freight transport networks at least in parts to present an accurate as-is situation. Recent developments outline possibilities to combine aggregated and disaggregated approaches in freight transport modelling. The objective is to obtain a more realistic representation of freight flows and underlying freight agent behaviour. In contrast to aggregated models, disaggregated approaches are able to simulate the decision behaviour on the micro-level of an individual decision maker (or rather firm level).

In maritime hinterland supply chains various decision makers interact (see figure 1). The market power has shifted from shippers being responsible for organising maritime and hinterland transport to liner carriers and freight forwarders. For instance, 60 percent of all liner carrier freight loaded or unloaded in German ports is controlled by sea freight forwarders (DSLV, 2015). Fransoo and Lee (2010) identify that in the Asia-Europe container trade even around 70% is contracted with carriers through freight forwarders. Notteboom (2008) agrees by asserting that on the European continent merchant haulage has the higher market share with approximately 70-90% of landside sea container transports. Thus, it can be assumed that 30-40 percent of German container hinterland transport is controlled by liner carriers/their agents and shippers with own transport departments, and 60-70 percent of German container hinterland transport is controlled by sea freight forwarders.

Economic choice situations in this environment are multifaceted and vary in terms of dependency, or frequency. Typical choices involve carrier and port choice but also mode and route choice. Decisions also vary in regard to one-time strategic or repetitive operational perspectives. In order to analyse these decisions different modelling and analysing methods are available. It can be argued that choices are too much simplified in order to apply rational method. The decision problem is not structured in a process-oriented way and connected situations are limited to a single decision. Considering this, one might also criticize that research stops prior to transferring new insights from the micro-level to macro-economic decision support tools.

This paper provides both an overview of present freight transport models with and without a logistics step and applied methods to study maritime supply chain freight agents' behaviour. Aim is to introduce a summarizing framework for behavioural freight transport modelling in maritime container supply chains. Finally, the concept is applied to a container hinterland transport model under development.

The paper is organised as follows. First, a literature review of present macro-economic freight transport models is performed. This is followed by a critical review of choice research in maritime supply chains. Second, a framework for container hinterland freight transport modelling is derived. Third, the framework is conceptually applied to a container freight transport model under development. Finally, the paper concludes with a discussion section.

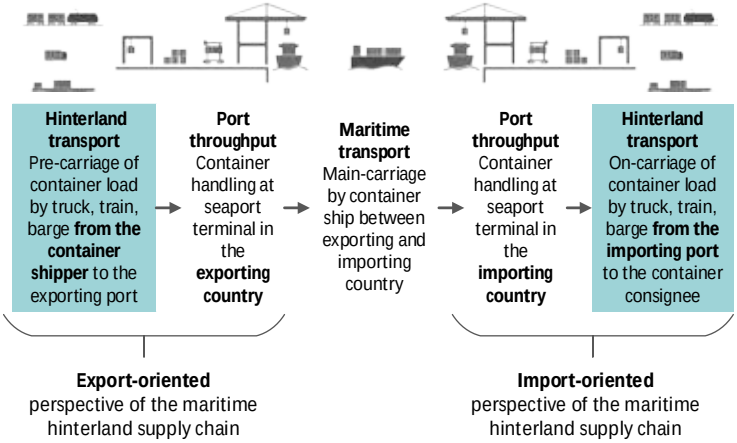

Figure 1 Maritime container supply chain

2 Literature Review

The literature review is twofold. Initially, it draws the attention to selection and classification of macro-economic freight transport models. Then, choices in maritime container supply chain research are reviewed.

2.1 Selection of Macro-Economic Freight Transport Models

Previous reviews on macro-economic freight transport models by de Jong et al. (2013), Tavasszy et al. (2012), Chow et al. (2010), Abdelwahab (1998), and on urban and metropolitan freight transportation by Taniguchi et al. (2014), Zhou and Dai (2012) guide the selection of models and classification

criteria. Besides, the authors performed a review of scientific articles on freight transport models and identified 111 articles published from 1970 to February 2015. These articles were scanned concerning new model developments.

Worldwide there are various transport models or separate (sub-) modules in operation. Developers are either academics and/or work for public organisations or private industries. As a result, model details can be confidential and are not published rigorously. Thus, selecting established and recent regional and national macro-economic freight transport models for this review requires some limitations:

- Sub-modules are not extra highlighted, e.g. models on mode and shipment choice.
- Only models developed between 2005 and 2015 or earlier models which are named in previous reviews are chosen.
- Freight transport models listed in past reviews and journal articles are only selected if information on classification criteria is regarded to be sufficient.

Finally, 14 macro-economic freight transport models are selected for review.

2.2 Classification of Macro-Economic Freight Transport Models

Figure 2 summarizes the 14 different macro-economic freight transport models according to the following classification criteria: client, geographical study area, years of development, modes, number of zones, number of commodities, modelling steps (generation G, distribution D, modal split M,

logistics L, assignment A), perspective (aggregated A, disaggregated D), and software.

Clients of the macro-economic freight model developers are national transport authorities or the European Commission. The study area mainly corresponds to the authority's' geographical area of responsibility or interest.

The basic model takes at least one to two years to develop but this period may be extended to up to five years depending on the model's features. All 14 models consider the modes road and rail, nine models add inland waterway, and seven models integrate sea, compared to six models including air. SCENES and SMILE+ contain all available transport modes including pipeline.

The number of geographical zones varies from 69 in BASGOED to 3101 in the NGVM. The average number of zones is about 650. The number of commodities ranges from five to 542 with 10 as the most frequent.

The modelling steps differ but except WFTM all follow in essence the classical 4-step approach which was originally developed for passenger transport. Building on this, several models replace the modal split step with a logistics step or add an additional logistics step between modal split and assignment.

Logistical choices diverge and may comprise shipment size choice, port choice, distribution centre choice, mode choice, vehicle type choice, or inventory choice. De Jong and Ben-Akiva (2007) refer to the number of legs in the transport chain, the use of terminals, and the mode used for each leg (including choice of vehicle/vessel type and loading unit) as 'transport chain choice'.

	1 ADA model for Flanders	2 BASGOED	3 German MFTM	4 GORM	5 SISD	6 NEMO	7 NGVM
Client	Flemish Ministry	Dutch Ministry	Basic funding of DLR	Swedish Admin.	Italian Ministry	Norwegian authorities	Swiss authorities
Study area	Flanders, Brussels, Belgium	The Netherlands	Germany	Denmark, Sweden	Italy	Norway	Switzerland
Years	2009-2010	2010-2011	Unclear	2008	2004	2004-2009	2009-2011
Modes	Road, rail, inland waterway, sea, air	Road, rail, inland waterway	Road, rail, inland waterway	Road, rail	Road, rail	Road, rail, sea, air	Road, rail
Zones	332	69	Unclear	296+	267	536	3101
Commodities	9	10	20	Unclear	5	32	118
Steps	G, D, L, A	G, D, M, A	G, D, M, A	Unclear	G, D, M, A	G, D, L, A	G, D, L, A
Perspective	ADA	A	AD	ADA	Unclear	ADA	ADA
Software	Own programm	Own programm	Visum	Unclear	Unclear	Own programm	Excel, Muuli, Visum

	8 SAMGODS	9 SCENES	10 SMILE+	11 TRANS-TOOLS	12 TREMOVE	13 UK Trans-Pennine	14 WFTM
Client	National authority	European Commission	Dutch Ministry	European Commission	European Commission	EU, UK department	Walloon region
Study area	Sweden	Europe	The Netherlands	Europe	EU + 8	UK	Belgium, Europe
Years	2004-2009	Unclear	1998-2005	2005-2009	1997-1998; 2002-2004	Prior to 2001	2006
Modes	Road, rail, sea, air	Road, rail, inland waterway, sea, pipeline	Road, rail, inland waterway, sea, pipeline	Road, rail, inland waterway, sea	Road, rail, inland waterway, air	Road, rail, inland waterway, sea, air	Road, rail, inland waterway
Zones	464	261+	117	1737	265	152	850+
Commodities	35	Unclear	542	10	Unclear	9	10
Steps	G, D, L, A	G, D, M, A	G, D, M, L, A	G, D, M, L, A	G, D, M, A	G, D, M, A	M, A
Perspective	ADA	AD	Unclear	AD	AD	ADA	Unclear
Software	Own programm	Unclear	Own programm	Various	Gams	Unclear	Nodus

Figure 2 Overview of macro-economic freight transport models

The majority of models show a disaggregated perspective. Especially, ADA models are established. In principal, aggregation refers to zone-to-zone flows and disaggregation to firm-to-firm flows. But the term disaggregation also relates to the conversion of shipment flows into vehicle flows, or the split of commodity groups into single commodities. ADA is applied by the ADA model for Flanders, SAMGODS, the NGVM and others.

Modelling steps and perspective are the logic behind the freight transport flow simulation. To integrate modelling steps and logic into geographical simulation different software tools are in available. Own programs are used frequently but also commercial freight transport modelling software like Visum and Nodus are deployed. Besides, commercial transport modelling software may be extended by own programs in external environments.

2.3 Choices in Maritime Container Supply Chain Research

Economics is about the choices individuals make, and micro-economics is the branch of economics that studies choice making (Krugman and Wells, 2013). Mathematical models as simplified representations of reality support this social research field heavily.

The root of choice modelling and analysis lies in two different decision theories. Descriptive decision theory concentrates on the psychology of individuals. It is also named empirical or behavioural decision theory and answers questions related to ‘what people do’. It is concerned with people's beliefs and preferences as they are, not as they should be (Kahneman and Tversky, 1984). Central research themes concentrate on how human choices derivate from rules of rationality. In contrast, normative or rational decision theory focusses on minimizing costs and maximizing benefits. It is

concerned with the nature of rationality and the logic of decision making (Kahneman and Tversky, 1984). Rational decision theory answers questions related to 'what people should do'. Especially after the findings of Kahneman and Tversky (1979) a rethinking of normative models of rational choice for analysing decision making under risk took place.

Today, rational choice models may be adapted to capture differences in decision weights and preferences of decision makers. Durbach and Stewart (2012) distinguish between analyses based on: probabilities, decision weights, explicit risk attributes, fuzzy numbers, and scenarios. To bridge the gap between micro-economic research and model application in the maritime transport business, the following questions guide the upcoming literature review:

- What is the decision problem?
- Who is the decision maker?
- Which main method is used for data collection?
- Which main method is used for decision modelling and data analysis?

95 journal articles published between 1973 and 2014 are identified.

2.3.1 Decision problem

Dominant decision problem in maritime supply chain research is port choice (55 publications), followed by liner carrier choice (18 publications) and mode choice (six publications). Table 1 gives an overview of all articles and the decision problems. Starting point in theory is a well-structured decision problem.

Table 1 Overview of decision problems in maritime supply chain research

Decision problem	References
Port choice (55)	Anderson et al., 2009; Bird and Bland, 1988; Bird, 1988; Brooks and Schellinck, 2013; Chang et al., 2008; Chou, 2007, 2009; Chou et al., 2010; Chou, 2010; de Langen, 2007; Ffrench, 1979; Fleming and Hayuth, 1994; Foster, 1978; Garcia-Alonso and Sanchez-Soriano, 2009; Guy and Urli, 2006; Ha, 2003; Itoh et al., 2002; Kim, 2013; Lam and Dai, 2012; Lee et al., 2010; Lirn et al., 2003; Lirn et al., 2004; Loon Ching Tang et al., 2011; Magala and Sammons, 2008; Malchow and Kanafani, 2001; Malchow and Kanafani, 2004; Mangan et al., 2002; McCalla, 1994; Murphy et al., 1992; Murphy and Daley, 1994; Ng, 2006; Nir et al., 2003; Notteboom, 2011; Saeed, 2009; Sanchez et al., 2011; Seo and Ha, 2010; Song, 2004; Starr, 1994; Steven and Corsi, 2012; Tavasszy et al., 2011; Tongzon and Heng, 2005; Tongzon and Sawant, 2007; Tongzon, 2009; Tran, 2011; Ugboma et al., 2004; Ugboma et al., 2007; Ugboma et al., 2006; van Asperen and Dekker, 2013; Veldman et al., 2011; Veldman and Bückmann, 2003; Wiegmans et al., 2008; Willingale, 1981; Yeo et al., 2014; Yeo et al., 2011; Yuen et al., 2012
Carrier choice (liner, 18)	Brooks, 1984; Brooks, 1985; Brooks, 1990, 1995; Chen et al., 2010; Chou and Liang, 2001; Collision, 1984; D'Este, 1992; Gibson et al., 1993; Kannan, 2010; Kannan et al., 2011; Kent et al., 1999; Lobo, 2010; Lu, 2003b; Nind et al., 2007; Pedersen and Gray, 1998; Saldanha et al., 2009; Wen and Huang, 2007

Decision problem	References
Mode choice (6)	Brooks et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Reis, 2014; Winston, 1981; Wong et al., 2008
Other (16)	Carrier choice (liner), port choice: D'Este and Meyrick, 1992; Murphy et al., 1991; Slack, 1985; Tiwari et al., 2003; Freight transportation choice (land): Mangan et al., 2001; McGinnis, 1979; Wang et al., 2014; Freight transportation choice (maritime): Talley and Ng, 2013; Talley, 2014; Thai, 2008; Carrier choice (land): Bardi, 1973; Murphy et al., 1997; Carrier choice (liner, air): Matear and Gray, 1993; Carrier choice (liner, land), mode choice: Meixell and Norbis, 2008; Logistics service choice: Lu, 2000; Maritime firm choice: Lu, 2003a

In practice, port and/or carrier choice problems are difficult to construct in a chronological and independent way due to, e.g. longer-term agreements, preferences of shippers, or different product life cycle stages (Flitsch and Jahn, 2014). Only three sources start their analysis by visually structuring the decision problem first. Mangan et al. (2002) highlight port choice as decision making 'process model'. Brooks (1990) introduce a 'decision flow diagram' named as ocean carrier selection model, and Brooks (1984) display the decision process in liner carrier choice as ‘decision tree’.

2.3.2 Decision Maker

Historically, the shipper was the main decision maker in maritime supply chains. With 17 publications it is still a highly researched area starting with

Bardi (1973) up to van Asperen and Dekker (2013). In addition, the shipper's agents carriers with 16 publications (Yeo et al., 2014; Willingale, 1981), carriers and freight forwarders with 14 publications (Chen et al., 2010; Brooks, 1984), and freight forwarders with 9 publications (Reis, 2014; Bird and Bland, 1988) are important research objects.

In 11 articles also shipments serve as a proxy for the group of all decision makers (Steven and Corsi, 2012; Winston, 1981). This refers to a revealed preference context where analysis of past choice and historical data takes place.

Other decision makers are named as carrier-shipper (Lobo, 2010), carrier-freight forwarder-shipper (Brooks and Schellinck, 2013), carrier-shipper-port (Talley, 2014), or as other actors and combinations (Sanchez et al., 2011).

2.3.3 Data Collection

Either no empirical data is collected or a questionnaire survey is conducted. Gathering statements of decision makers with (semi-) structured questionnaires is by far the most widespread main empirical data collection method with 37 papers, for instance see Brooks and Schellinck (2013) or Foster (1978).

15 articles concentrate on interviews for getting data (Yuen et al., 2012; Willingale, 1981), five current publications use discrete choice experiments (Brooks et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Nind et al., 2007; Wen and Huang, 2007).

Kannan et al. (2011) and Kannan (2010) organize focus groups. No empirical data collection takes place in 36 papers (see Reis, 2014; Ffrench, 1979).

2.3.4 Decision Modelling and Data Analysis

Table 2 lists the main methods for decision modelling and data analysis applied in maritime supply chain research. Statistical analysis (descriptive, inferential) directed towards the identification of main decision attributes is applied in 37 publications. Theoretical contributions are made in 18 papers. Discrete choice models are of relevance in 16 articles. Additionally, the Analytical hierarchy process (AHP) is a popular analysis method applied in 8 publications.

Prior to 2003 research concentrated mainly on decision attribute identification and weighting with descriptive statistical analysis methods. Since 2003 further application of identified decision criteria and preference weights takes place, e.g. to estimate market share changes of carriers (Wen and Huang, 2007; Tiwari et al., 2003), to derive a demand function for traffic forecasting (Veldman and Bückmann, 2003), to formulate a optimization programming model for the port choice of shippers (Chou, 2009), or a combined fuzzy MCDA / optimization programming model (Chou et al., 2010), and to propose a web-based decision support system for port selection (Lam and Dai, 2012).

Table 2 Overview of main method for data analysis in maritime supply chain research

Decision problem	References
Statistical analysis (descriptive, inferential)	Bardi, 1973; Brooks, 1984; Brooks, 1985; Brooks, 1990, 1995; Brooks and Schellinck, 2013; Chang et al., 2008; Chen et al., 2010; de Langen, 2007; D'Este and Meyrick, 1992; Foster, 1978; Gibson et al., 1993; Ha, 2003; Kent et al., 1999; Kim, 2013; Lee et al., 2010; Lobo, 2010; Lu, 2000, 2003a, 2003b; Mangan et al., 2002; Matear and Gray, 1993; McGinnis, 1979; Murphy et al., 1991; Murphy et al., 1992; Murphy and Daley, 1994; Murphy et al., 1997; Ng, 2006; Pedersen and Gray, 1998; Saeed, 2009; Sanchez et al., 2011; Slack, 1985; Thai, 2008; Tongzon, 2009; Ugboma et al., 2004; Ugboma et al., 2007; Yeo et al., 2011
Theoretical	Chou, 2007, 2009; Chou et al., 2010; Chou, 2010; Chou and Liang, 2001; Ffrench, 1979; Loon Ching Tang et al., 2011; Magala and Sammons, 2008; Notteboom, 2011; Seo and Ha, 2010; Talley and Ng, 2013; Talley, 2014; Tavasszy et al., 2011; Tongzon and Heng, 2005; Tongzon and Sawant, 2007; Tran, 2011; Wang et al., 2014; Yeo et al., 2014
Discrete choice	Anderson et al., 2009; Brooks et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Garcia-Alonso and Sanchez-Soriano, 2009; Itoh et al., 2002; Malchow and Kanafani, 2001; Malchow and Kanafani, 2004; Nind et al., 2007; Nir et al., 2003; Steven and Corsi, 2012; Tiwari et al., 2003; Veldman et al., 2011; Veldman and Bückmann, 2003; Wen and Huang, 2007; Winston, 1981

Decision problem	References
Analytical hierarchy process	Kannan, 2010; Kannan et al., 2011; Lirn et al., 2003; Lirn et al., 2004; Song, 2004; Ugboma et al., 2006; Wong et al., 2008; Yuen et al., 2012
Other	Descriptive analysis: Bird, 1988; D'Este, 1992; Wiegmans et al., 2008; Willingale, 1981; Simulation: Guy and Urli, 2006; Reis, 2014; Saldanha et al., 2009; van Asperen and Dekker, 2013; Literature review: Mangan et al., 2001; Meixell and Norbis, 2008; Market analysis: McCalla, 1994; Starr, 1994; Case study analysis: Collision, 1984; Conceputal analysis: Lam and Dai, 2012; Content analysis: Bird and Bland, 1988; Spatial analysis: Fleming and Hayuth, 1994

3 Framework for container hinterland freight transport modelling

It can be stressed that a long experience in passenger transport modelling in academia is a good starting point for modelling freight transport flows. Modelling practices are transferred. However, freight transport is far more complex than passenger transport. Decision makers and their power to act vary due to contractual and non-contractual relationships, e.g. freight forwarders may chose a port corresponding to a shipper's preference or because they have long-term volume agreements with liner carriers departing from that port. Transported goods differ in volume, urgency, or value. Empty loading units and vehicles require capacity, too. Further, container

hinterland transport and mainland transport face different risks; say ship delays are not in the forwarders sphere of influence. In summary, it is possible to transfer passenger modelling practices to container hinterland supply chains. But realistic models of the as-is situation need to be capable to consider at least parts of the system's complexity.

The main research objective is to determine (1) how decision problems in container hinterland supply chains can be structured according to decision maker and freight category, (2) how identified decision problems may be modelled and analysed, (3) how to apply the results in a freight transport model under development and, (4) how the final freight transport model output may be validated.

By taking the literature review of both macro-economic freight transport models and choices in maritime container supply chain research into account, a simple framework for container hinterland freight transport modelling is proposed (see figure 3).

	STRUCTURE	MODEL & ANALYSE	APPLY	VALIDATE
Methods	Business process modelling	Discrete choice	Value functions	Sensitivity analysis
	Soft system methodology	Analytical hierarchy process	Preference weights	Case study
	System dynamics ...	...	...	...

Figure 3 Framework for container hinterland freight transport modelling

3.1 Structure

Graphical representation of decision situations is an accepted method for problem structuring and segmentation of decision makers.

As highlighted previously, three publications in supply chain choice research start their analysis by visually structuring the decision problem first. Mangan et al. (2002) depict a process model, Brooks (1990) introduces a decision flow diagram, and Brooks (1984) applies a decision tree.

Apart from this, the business process modelling method is selected in several PhD dissertations in maritime logistics research. Advantage is that not only choice dependencies but also decision makers can be visualised. Wolff (2014) models different business processes in empty container logistics. Will (2011) concentrates on RFID implementation to maritime container logistics and transshipment process optimisation. Zuesongdham (2010) models a reference process for project and heavy-lift cargo. Schwarz (2006) simplifies process models in tri-modal hinterland transport chains.

Other advanced problem structuring methods have been developed pragmatically and are own research fields in operations research (Mingers and Rosenhead 2004). Potential drawback is that in contrast to business process modelling decision makers in maritime supply chains are usually not acquainted to methods like soft system methodology, or system dynamics. This could hinder empirical data collection.

3.2 Model & Analyse

After reviewing the literature on methods to model and analyse choices in maritime container supply chain research, the acceptance of discrete

choice models and the AHP in empirical research became apparent. Especially, after 2003 research moved further than identifying significant decision attributes to calculating preference weightings of rational decision makers.

The AHP is rooted in multi criteria decision analysis (MCDA) which is a subdiscipline of OR. Main idea is to aid subjective decision making by integrating objective measurement with value judgement (Belton and Stewart, 2002). The AHP is a structured MCDM technique for organizing and analysing complex decisions quantitatively based on qualitative human judgment (pairwise comparison of choice attributes). It supports the identification of the relative value of a previously identified choice attribute set in hierarchical order to reach a final decision.

By contrast, discrete choice models calculate choice probabilities derived from utility maximizing behaviour of the decision maker. Different models (e.g. the most popular multinomial logit MNL) start their analysis with an underlying rational decision process displayed in a functional form - the utility function consisting of a value function and an error term. Key thoughts are that the decision maker tries to maximize the individual value function, makes trade-offs between attributes and that an error term captures all other influences.

3.3 Apply

Results of the AHP are absolute values of preference weights for single decision attributes which can be ranked accordingly. Previously AHP helped to explore the relative importance of factors that determine container port

competitiveness and to rank them (Yuen et al., 2012), to examine predominant factors for port choice (Ugboma et al., 2006), or to assist ocean container carriers in benchmarking their service quality (Kannan, 2010).
The outcomes of discrete choice analysis are preference estimates of the choice attributes and corresponding probability weights of two or more choice alternatives. Both help to predict future choice behaviour. Ben-Akiva and Lerman (1985) introduced the method to travel demand analysis. Today, discrete choice analysis assists to model the modal choice between door-to-door road transport and short sea shipping (Feo et al., 2011), to establish a demand function for container port services (Veldman et al., 2011), or to estimate market shares of freight agents (Wen and Huang, 2007; Tiwari et al., 2003). Additionally, discrete choice analysis may result in dedicated cost functions for transport flows which also include a quantification of qualitative choice criteria (see most comprehensive values of time and values of reliability for shippers and freight forwarders determined by de Jong et al. in 2014).

3.4 Validate

Sensitivity analysis and case studies supported by historical data analysis are possible methods to validate container hinterland freight transport model outputs. Changes in variable levels on output impact may be examined to adjust the model design in an iterative way. A prevailing risk is that data to validate the model cannot be or has not been collected by the researcher/others or that access to historical data is denied (confident, or no interest to share).

4 Application of the Framework to a Container Freight Transport Model

Client of the macro-economic container freight transport model under development is the Ministry of Science and Research of the City of Hamburg. Study area is the regional, national and international hinterland area of the Port of Hamburg. For the base model a two year development period with start in 2014 is anticipated. All modes of relevance for container hinterland transport are considered, thus, road, rail and inland waterway. The classical 4-stage model of transport modelling (generation, distribution, modal split, assignment) is enlarged by transferring the modal split choice into a combination of supply chain choices under the umbrella term 'logistics choice'. The previously proposed framework for behavioural freight transport modelling sets in here. Figure 4 displays the methods which are considered for application based on the previous framework.

Main parts of the model's logic are supported by the software environment Visum but the disaggregation logic of the followed ADA perspective is programmed externally. These external calculations are passed back to Visum for final simulation of freight transport flows onto the geographical road, rail and inland waterway network.

Input data consisting of structural data, transport networks, and production/distribution/consumption figures is enlarged by the generated decision process models of the maritime hinterland supply chain. The process models are essential for modelling and analysing freight agents' preferences in different maritime hinterland supply chains with discrete choice models. Altogether, the steps 'structure' and 'model & analyse' are key for

integrating behavioural differences of freight agents container hinterland transport flows.

The model's output comprises transport matrices and network loads. In order to validate the quality case studies with freight agents enable the researcher to compare results with historical data.

On the one hand, further research relates to base model extension. On the other hand, model application stimulates further research, exemplary, in the domain of transport forecasts and scenario analysis, location and potential analysis, environment and safety analysis as well as infrastructure and policy measure planning.

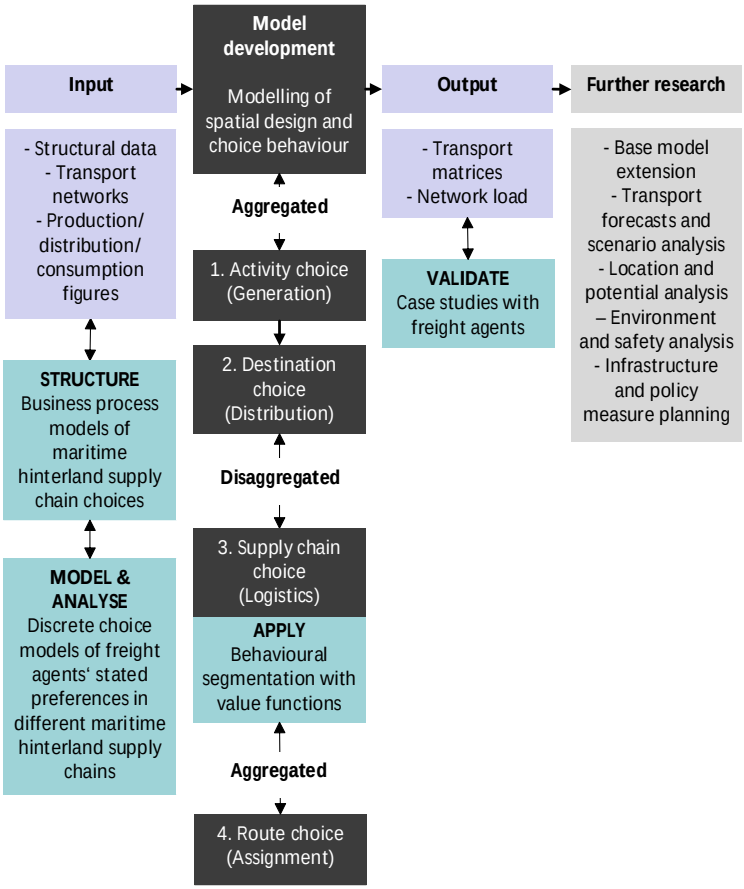

Figure 4 Conceptual representation of the container freight transport model

5 Discussion and Conclusion

Compared to the sophistication of passenger transport models, their underlying decision logic and supporting practices, freight transport models lag behind. This paper does not strive for radical innovations but for stressing the importance to combine established methods in a structured way. Apart from high demands on mathematical choice models to consider uncertainty, risk and decision power other issues complicate research progress. Getting data access is one major hindrance in the logistics environment and collecting the data can be costly. If decision makers do not understand why or how to supply their input for freight transport modelling projects the validity of realistic transport flows is likely to be low.

To conclude, this paper provides an overview of both recent freight transport models, and on accepted methods for choice analysis in maritime supply chain research. As a next step the researchers have the opportunity to use and evaluate the framework while working on the container transport freight model under development. By this, research would not stop prior to transferring new insights from the micro-level to macro-economic decision support tools.

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