An application of quantitative and qualitative methods in freight mode choice modelling

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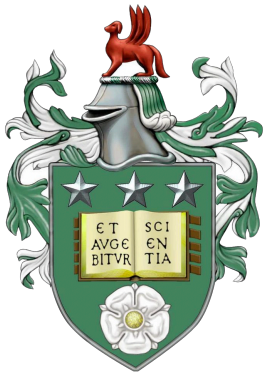
Doctor of Philosophy



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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

To my family

Acknowledgements

In 2012, I came to the University of Leeds to pursue an additional master in sustainability studies after my studies in economics in Ghent (Belgium). The plan was to get the degree and find my way, but then something quite different happened. I'm very grateful for the given opportunity to research a topic of my interest for the past four years. Now, Leeds is my second alma mater where I can look back many good memories.

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Abstract

European policy-makers set specific GHG targets and goals towards a freight transport modal shift away from the road mode towards alternative modes such as rail and inland waterways. Understanding individual mode choice behaviour forms an important component in the discussion on a freight modal shift. The research presents a mixed methods freight study conducted with logistics managers of freight shippers' companies in the Port of Ghent region. The mixed methods design followed is that of a convergent design with quantitative priority. Quantitative choice modelling techniques are applied to address the impact of transport time, transport cost (tariff), loss and damage, reliability and CO_2 emissions. Policy-relevant willingness-to-pay measures such as the value of time, value of reliability, value of loss and damage and value of the environment are derived from MNL and MMNL model results to complement the freight mode choice literature. In addition, the impact of environmental attitudes on freight mode choice is assessed by applying an ICLV model framework. This is the first freight ICLV to account for such underlying environmental attitudes on mode choice. The qualitative thematic analysis is applied to gain in-depth understanding of the company contextual setting in which freight mode choices are made in practice, to gain understanding on the experiences of the respondents in relation to the SP survey and to map perceived barriers and triggers to a regional modal shift. The qualitative analysis resulted in interesting findings which imply to further incorporate the role of production processes and inventory logistics in freight mode choice analysis and freight SP as well as valuable insights to inform the regional policy level. Integration between qualitative and quantitative data takes place at the collection, analysis and interpretation research phases. Findings from the two techniques are used to strengthen or nuance one and another. Also, an ICLV model framework is presented to include qualitative themes into an extended choice model framework.

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Figures and Tables

List of Abbreviations

CAPI: Computer Aided Personal Interviewing
CBA: Cost-Benefit Analysis
DCM: Discrete Choice Modelling
GEV: Generalised Extreme Value
ICLV: Integrated Choice and Latent Variable
IIA: Independence from Irrelevant Alternatives
iid: independent and identically distributed
IWW: Inland Waterways Mode
JIT: Just-In-Time Transport
LASP: Leeds Adaptive Stated Preference
MM: Mixed Methods
MMNL: mixed multinomial logit with random taste heterogeneity
MNL: multinomial logit
PoG: Port of Ghent
RP: Revealed Preferences
RRM: Random Regret Minimisation
RUM: Random Utility Maximisation
SP: Stated Preferences
SSS: short sea shipping mode
TA: Thematic Analysis
VO_ENV: value of the environmental attribute
VO_LD: value of loss and damage
VOR: value of reliability
VOT: value of time
WTP: willingness-to-pay
WTP ENV: willingness to pay environment
WTP LD: willingness to pay loss and damage

1. Introduction Chapter

This chapter serves to introduce the reader to the research topics. The setting or background of the research problem will be outlined in section 1.1, followed by the research questions listed in section 1.2. The last section of the introduction chapter provides the reader with an outline of the structure of the thesis manuscript (section 1.3).

1.1. Freight transport and environment: setting the research problem

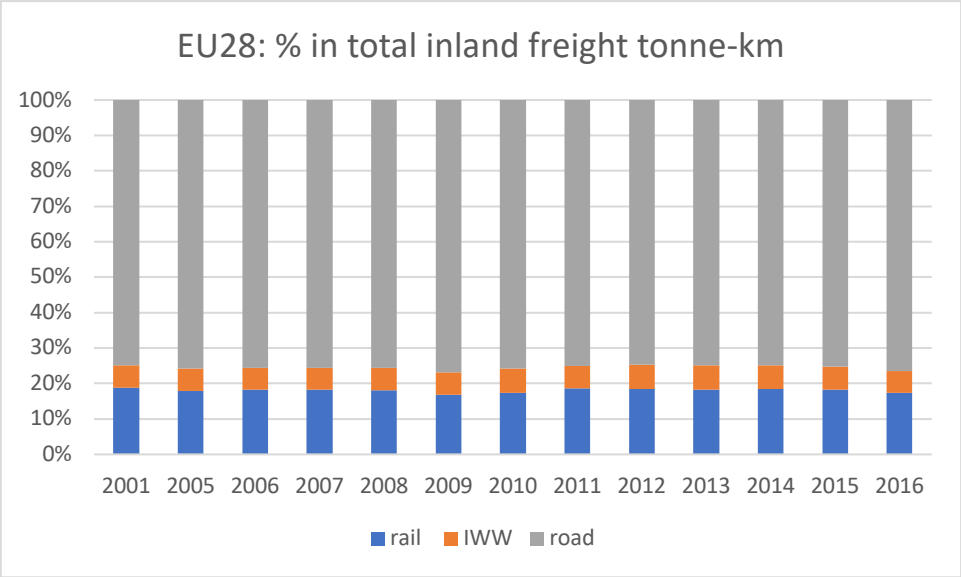
The landscape of freight transport policy in Europe has changed since the European Commission's 2001 White Paper on Transport Policy. The impact of the road transport sector on the environment has since become increasingly present in European policy-making. The 2001 White Paper laid out a road map towards an integrated European transport network, which was then updated in 2011 to include clearly defined environmental targets in terms of emissions and a modal shift. Specifically, a target of a 50% shift from road to rail and waterborne modes for medium distance freight transports by 2050 was set (EC, 2011). However, based on the latest available number in the Eurostat database, no significant shift in the modal split for the EU28 is visible (Figure 1). It needs to be clarified that the Eurostat database describes road transport based on all movements of vehicles registered in the EU countries, whereas the rail and inland waterways (IWW) transports are based on reported movements in the countries independent from the nationality of the vessels. Figure 1 shows a dominant percentage share of road transports over the 2001 – 2016 timeline, which covered a 76.4 % share in 2016.

Similar road dominance in terms of % share for inland freight transports is present in the Belgian modal split (Figure 2). However, the reported Belgian rail mode percentage shares are lower than the European average and the reported inland waterway percentage shares are consistently higher over 2005 until 2016 compared to the European average.

Next to the key European objectives that were set in terms of freight transport modal split shares, clear targets were formulated in relation to GHG emissions as the transport sector

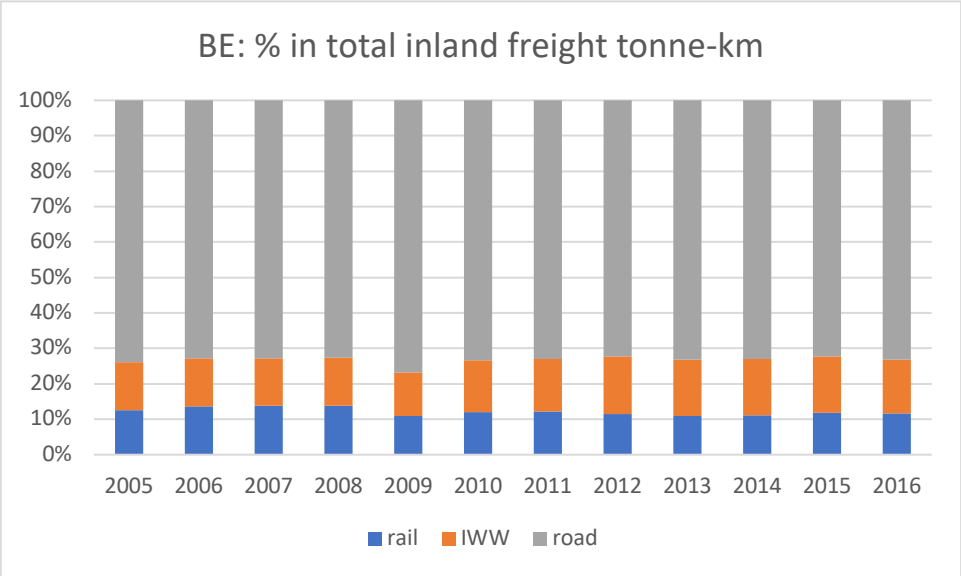
(freight and passengers) contributes to a large share in the total emitted GHG emissions in the EU. In 2016, the transport sector contributed 20% of the total EU-28 GHG emissions, excluding international aviation and maritime transports (EEA, 2018). A target to reduce these emissions by 60% by 2050 was put forward (EC, 2014). In terms of greenhouse gas emissions originating from transport (and storage), available data from Eurostat indicates a decrease of 8.2% between 2008 and 2016 (Eurostat, 2017).

Figure 1: Modal split EU28 (excluding air and maritime)



Source: Eurostat (2018)

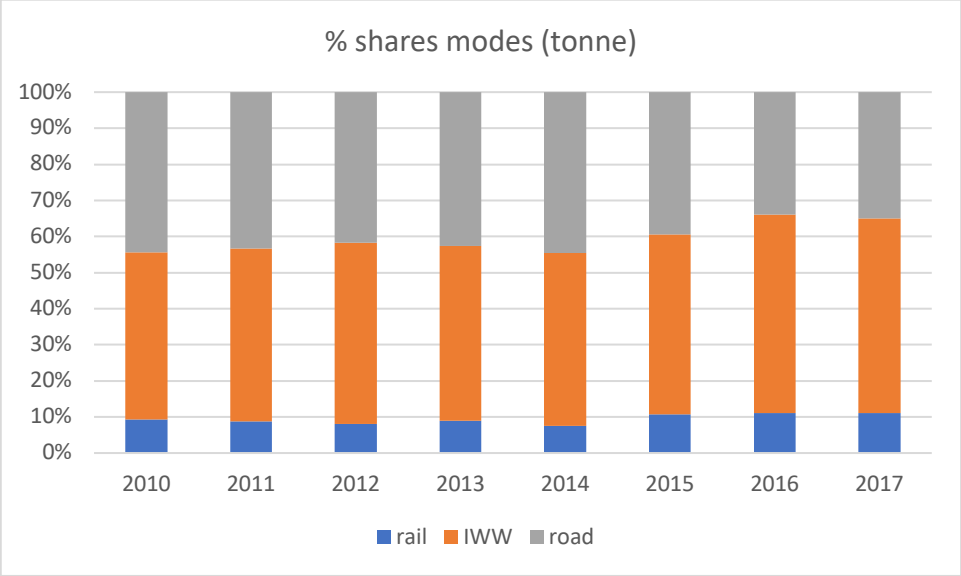
Figure 2: Modal Split Belgium (excluding air and maritime)



Source: Eurostat (2018)

The case study of the research is set in the Port of Ghent region in Belgium. The modal split numbers show a different image for the Port of Ghent when comparing these to the Belgian modal split and the European region modal split. The regional modal split of the Port of Ghent for the outgoing flows would indicate a larger percentage shares of the inland waterways transport mode (Figure 3). However, it needs to be clarified that the percentage shares for the Port of Ghent are per tonne, whereas the European and Belgian percentage shares are per tonne-km. However, only data per tonne was available from the Port of Ghent Authority, which makes direct comparison difficult. The objectives set by the Port of Ghent Authority (now called North Sea Port) are to achieve a modal split of 15% by rail, 35% by road and 50% for inland waterways by 2020 for outgoing flows. Only the rail mode has not been able to reach this target, while the inland waterways mode has already surpassed it.

Figure 3: Modal split Port of Ghent (outgoing transports)



Source: Port of Ghent (2017) and North Sea Port (2018)

European, national and regional targets are set in terms of attaining a freight modal shift, from the road mode towards more sustainable modes. It is in this European policy and regional context that freight shipper's companies operate. The research emphasis lies on individual freight mode choices made by these companies, since they collectively determine the modal split. It is argued that the logistic manager of freight shipper's companies are the key-drivers in determining these mode choices in the Port of Ghent region.

Firstly, the research aims at understanding the impact of important freight factors on individual logistic managers' preferences relating to mode choice. The freight mode choice literature identifies multiple key-factors that impact mode choice, such as transport time, transport cost, reliability of the service, frequency of the service, loss and damage, and others. Based on the literature, it was decided to include the transport time, transport cost, reliability and loss and damage as attributes in the freight stated preferences survey. However, the inclusion of an environmental factor in freight mode choice studies is only scarcely found. Considering that specific European and national targets of GHG reductions directed at freight transport and objectives for a modal shift towards more sustainable modes are set, it is likely that the environment will increasingly play a role in decision-making on freight transport choices. Therefore, this study adds to the literature by also assessing the impact of an environmental attribute on logistic managers' preferences relating to mode choice. In doing so, this research aims to provide an additional willingness to pay measure for the environment to the existing literature. This measure could serve as a benchmark for further freight mode choice studies and as an input for general transport models and policy decision-making. In addition to the environmental attribute, environmental attitudes specified on the individual level and corporate level are included in the analysis. Mode choice studies in the passenger literature have reported that environmental attitudes play a role (among other variables) when deciding upon a personal mode of transport. However, the freight mode choice in this application is made by the logistic manager for his or her company. This implies that not only the individual attitudes could potentially play a role, but also the perceived environmental outlook of the company which is referred to as "corporate attitudes". The latent nature of such psycho-metric constructs is recognised and an integrated choice and latent variable (ICLV) model framework is applied to include such environmental attitudes. This is in line with the choice modelling literature, which argues that the ICLV framework is more appropriate to include such psycho-metric constructs. Up to the knowledge of the researcher, this is the first model that employs an ICLV model to account for underlying environmental attitudes of logistic managers in freight shipper's companies in their mode choices.

The data to assess the impact of transport time, transport cost, loss and damage, reliability, the environmental attribute and underlying environmental attitudes specified to either the

individual level or corporate level is collected by a stated preference (SP) experiment and an attitudinal questionnaire with the logistical managers of freight shipper's companies.

Secondly, the research aims at gaining insights in the company contextual setting, in which freight mode choices are made in practice. This is done for two main reasons. On the one hand, to gain an in-depth understanding of freight mode choices in practice specifically to the regional context of the Port of Ghent. These insights can serve as inputs for the regional policy-level. On the other hand, freight stated preferences experiments have their limitations in being hypothetical in nature and choice tasks only include predetermined factors as chosen by the researcher. It is unfeasible to include all relevant factors found in the literature in a stated preferences freight study. Therefore, this research has opted to complement the freight SP choice tasks by qualitative open-ended interviews in order to gain insights on the contextual setting of the choices made in practice as well as to gain insights on the experiences of the respondents with the SP survey. It is aimed that these qualitative insights are not just useful for to the regional policy-level, but also, by adding additional factors that can be researched for future freight SP.

Thirdly, as the collective of individual mode choices determines the modal split in the Port of Ghent region, the focus is shifted towards gaining insights on the potential triggers and barriers as perceived by the logistic managers in order to attain the modal shift targeted by policy-makers away from the road mode towards more sustainable modes. The point of view of freight shipper's companies, analysed thematically by making use of qualitative interview data, are the central focus of this research. It is hoped that these findings will inspire regional policy makers.

Three different topics can be identified: freight mode choice, contextual setting of mode choice and modal shift. For each topic, specific research questions are formed. Both quantitative (choice modelling) and qualitative (thematic analysis) techniques are used to address these. The research follows a mixed methods convergent design, wherein quantitative techniques are prioritised. This implies that the emphasis is on the quantitative methods in terms of integration as well as interpretation if findings from the two techniques

might contradict one and another. The specific research questions and the identified analysis methods are listed in the next section.

1.2. The research questions

1.2.1. RQ set 1: Freight Mode Choice

Understanding freight mode choice with regards to its specific corporate context and the impact of key-identified variables upon mode choice motivates the first set of research questions. These impact-variables are: transport time, transport cost (tariff), reliability, loss and damage, CO_2 emissions, individual environmental attitudes and the perceived corporate environmental outlook by the respondent (or "corporate attitudes").

The selection of transport time, transport cost (tariff), reliability, loss and damage as attributes are motivated based on the existing freight mode choice knowledge-base. Relevant freight mode choice studies were taken into consideration and the different attributes that were found significant are listed in overview Table 1 (chapter 2, section 2.6). Based on this table, it became clear that these four attributes are key-attributes across studies and have been established as significant determining factors in freight mode choice. Following this, these identified attributes could not be absent from this mode choice study. In addition, the choice to include an environmental attribute is driven by the research interest in the role of the environment and the policy-relevant context of a freight modal shift towards more sustainable transport modes as described in the previous section. However, studies in the freight mode choice literature that include an environmental attribute are rather scarce, as will be discussed in the literature review. Considering this, it was opted to be consistent in terms of framing the environmental attribute with the existing study of Fries et al. (2010), which will serve as a benchmark. This has led to the inclusion of a measure of CO_2 emissions to account for an environmental attribute potentially impacting freight mode choice (RQ1.A).

> **RQ1.A: What is the impact of transport time, transport cost (tariff), reliability, loss & damage and CO_2 emissions on logistics managers' preferences with regards to freight mode choice?**

In the passenger mode choice literature, a significant effect has been found of the environmental attitudes of individual decision-makers with regards to choosing greener alternatives such as cycling or choosing an electric car (see for example the work of Bahamonde-Birke and Hanappi (2015) on electromobility). In the context of this study, individuals need to make freight mode choices on behalf of their company. These choices reflect trade-offs between faster, cheaper, more reliable, less loss and damage and greener options. Although the choice is for the company, it is still made by the individual decision-maker. Therefore, their personal attitudes towards the environment might potentially impact these choices (RQ1.B). As stated, the choice is made for the company which the decision-maker can perceive to be environmentally friendly oriented or not. Therefore, the perceived environmental outlook of the company might also be potentially reflected in the mode choices made by the decision-maker (RQ1.C).

RQ1.B: What is the impact of the decision-maker's personal environmental attitudes on freight mode choice for his or her company?

RQ1.C: What is the impact of the company's environmental attitudes perceived by the decision-maker on freight mode choice for his or her company?

RQ1.A is addressed using stated preferences data upon which choice modelling techniques are applied. In particular, the multinomial logit and mixed logit model were applied to derive sensitivities with regards to the different attributes. From these sensitivities, relevant policy measures (such as the value of time (VOT), value of reliability (VOR), willingness to pay with regards to loss and damage (WTP LD), willingness to pay for the environment (WTP ENV)) can be derived and the findings can further serve as input values, to be combined with revealed preferences data estimates into a general four-step transport model. RQ1.B and RQ1.C expand on the previous questions by combining choice data with attitudinal data applying an integrated choice and latent variable (ICLV) model framework.

RQ1.A till RQ1.C can be understood as questions of quantification ("how much" impact on mode choice) and valuation. It is important to repeat that the mode choices have a hypothetical nature, as the choices are derived using a stated preference survey. Yet, they are made by real decision-makers that make these freight mode choices in their daily working life. Whereas the questions above result in policy relevant measures of valuation, they do not

provide insight into the specific company dependent context in which they are made. In particular, it is not unrealistic to assume that the specific business context for each of the decision-makers is considered when making the choices, as these are made for that particular business organisation. However, designing a quantitative survey implies that a trade-off needs to be made between simplicity and the inclusion of various relevant variables. It was decided to address the question of the specific corporate context using qualitative interviews, as open-ended semi-structured interviews provide an opening to follow-up and go in-depth into the reasoning of the decision-makers.

RQ1.D: In what context are freight mode choices made?
RQ1.E: What is the specific business context in which these choices are made?

1.2.2. RQ set 2: validation of SP choices

The second set of research questions relates to the experiences of the decision-makers in relation to the SP choice tasks. The reason for why SP was used, its hypothetical nature and its benefits and disadvantages are discussed in the survey chapter (CH4). However, it is important to repeat that the choices made in the choice tasks are of a hypothetical nature. While pivot techniques were applied to make the choices more realistic, questions still remain with regards to the *"realism"* of such choices compared to real-life practice. It was decided to combine the SP survey with open-ended semi-structured interview questions which address the perceived *"realism"* of such choices. This qualitative interview approach would allow for an in-depth exploration of the experiences of the decision-maker with the SP choice tasks, while also exploring on the comments made during and after the SP survey. In addition, the CAPI technique (Computer Aided Personal Interviewing) to conduct the SP survey lends itself to be complemented by additional qualitative interviewing without too much difficulty. It needs to be noted that the letter "P" in the CAPI terminology refers to the PhD candidate herself in this application. In other words, both the qualitative and quantitative interviews were carried out by the PhD candidate.

RQ2.1: Are the SP freight choice alternatives representing decision-making in real-life practice?
RQ2.2: What are the experiences and reflections of the decision-makers during the SP choice tasks:

RQ2.2.b: How did the interviewees perceive the SP survey?
RQ2.2.c: Why are some choices made?
RQ2.2.d: What is the reasoning behind certain comments made during the choice tasks?
RQ2.2.e: What were the main difficulties experienced by the participants?

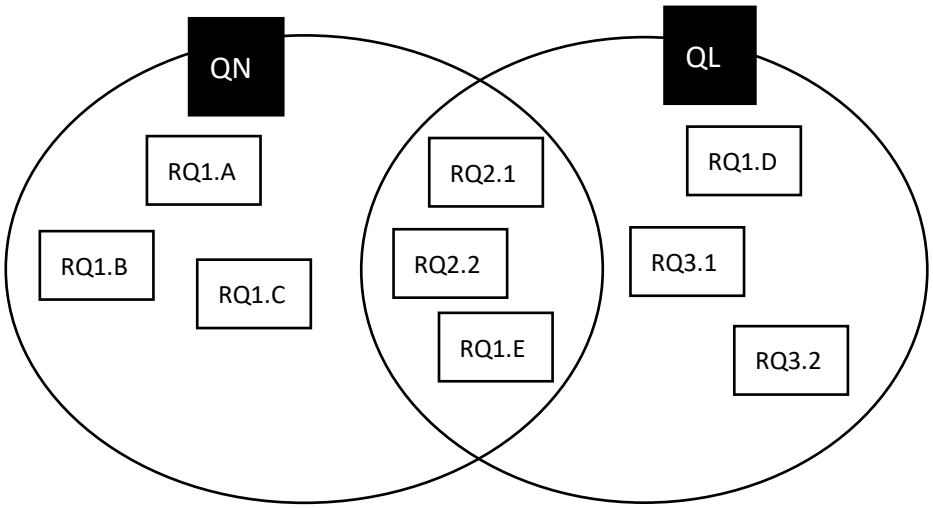
1.2.3. RQ set 3: freight modal shift

The third and final set of research questions relates to the topic of a freight modal shift towards more sustainable modes. Section 1.1 indicated that current EU policy modal split targets have not yet been reflected in the modal split numbers. On the one hand, understanding the impact on individual mode choice preferences provides indicators for mode choice behaviour in practice (RQ1.A, RQ1.B. & RQ1.C). On the other hand, as individual mode choice behaviour collectively forms the modal split, questions need to be asked about the perceived triggers of a change towards using more sustainable freight modes from the point of view of the decision-maker in the market. In other words, the qualitative part of the interviews serves to listen to the perceived challenges of the actual decision-makers of mode choice in the market. To address these, in-depth qualitative interview questions were asked, forming the last component of the data collection process.

RQ3.1.: What are the perceived triggers of change with regards to a modal shift towards more sustainable modes in the case-study area?
RQ3.2.: How is the company context perceived in relation to a modal shift?

These three sets of research questions are answered using two main research techniques (Figure 4), namely that of choice modelling on stated preference choice data and attitudinal data (quantitative) and thematic analysis using node coding upon transcribed open-ended semi-structured interviews (qualitative). Combining and integrating these have led to a classification falling under a mixed methods methodological framework.

Figure 4: Positioning research questions



The next section provides the reader with a brief overview of the manuscript's structure.

1.3. Manuscript structure

The manuscript is structured as follows.

Chapter two gives an overview of the freight mode choice literature, as the research is positioned in the freight transport demand field. The chapter discusses the modes, attributes, model structures and types of data which are most dominantly used in the literature. An overview table is provided, listing relevant found freight mode choice studies.

Chapter three discusses the methodology. As the research follows a mixed methods methodological design, both the quantitative and qualitative techniques will be highlighted. However, it can be noted that the quantitative models are more extensive and more pervasive in this research, which coincides with the type of mixed methods design followed, namely convergent with quantitative priority.

The fourth chapter gives an introduction to the case study area of the Port of Ghent region and discusses the integrated survey design, which consists of qualitative interview questions, freight stated preferences choice tasks and an attitudinal questionnaire.

Chapter five includes three subchapters on the research's main results. Firstly, subchapter 5.1. lists the solely quantitative derived modelling results with regards to the impact of transport time, transport cost, loss and damage, reliability, CO_2 emissions and environmental attitudes. Based on the model results, the policy-relevant willingness to pay measures are derived and compared across the different model structures (multinomial logit and mixed multinomial logit with random taste heterogeneity). Secondly, subchapter 5.2. provides the qualitative insights on the contextual factors of freight mode choices made in practice and the perceived *"realism"* of the SP choice tasks. In addition, it reports on preliminary model results that integrate the derived qualitative factors into an integrated choice and latent variable model. Thirdly, subchapter 5.3. highlights the qualitative derived findings on the perceived barriers and triggers of change to attain a modal shift in the regional context of the Port of Ghent.

The model estimation results and qualitative insights with regards to mode choice in practice, SP *"realism"* and the modal shift topic are discussed in chapter six. Different results and insights are combined to strengthen or nuance one and another. The chapter includes acknowledgements of the limitations of the research and references for future research that came to the surface when interpreting the results and insights. In addition, key take-away points for policy-makers are listed.

The manuscript ends with a concluding chapter, which briefly highlights the main findings again, followed by the bibliography (chapter 8) and appendix (chapter 9).

2. Freight transport demand: mode choice

2.1. Introduction

Freight transport has come a long way in terms of modelling, in which these models serve their purposes in many national and international policy contexts (Ben-Akiva et al. 2013). The reference books of Tavasszy and de Jong (2014) and Ben-Akiva et al. (2013) provide an introduction and overview of the trends in freight transport modelling. Alternatively, the paper of de Jong et al. (2004) provides a structured and concise overview of the different techniques used at every step of the 4-step modelling approach for freight transport. The research put forward in this doctoral thesis is positioned at the freight demand side, in particular with an emphasis on mode choice.

Freight transport demand in terms of mode choice addresses the distribution of total demand for freight transport over different modes. It has broadly speaking been approached in two manners: either at an aggregate level or disaggregate level (de Jong et al., 2013).

Mode choice models on the aggregate level, commonly referred to as freight modal split models, are usually based on origin-destination (OD) matrixes and are commonly found in the freight literature and widely used at the policy level. For example, the national French freight transport model (MODEV) is characterised by a modal split model using aggregate data over the road, rail and inland waterways modes (MVA and Kessel + Partner (2006) in de Jong et al., 2013). An argued advantage of aggregate data is the wide availability compared to disaggregate data. However, de Jong et al. (2004a) emphasise that aggregate models have the disadvantage of weaker underlying theoretical frameworks and offer little explanation on causal relations.

In contrast, a disaggregate approach makes use of data of individual firms and/or shipments. Such models are conventionally referred to as mode choice models. Interesting to note, the decision maker is conventionally simplified to a single firm decision unit. It is acknowledged in the literature, however, that interactions can be present between senders, receivers and carriers of cargo (as expanded upon in Tavasszy & de Jong, 2013). The work of Hensher and

Puckett (2007) and Hensher, Puckett and Rose (2007) provides an interesting approach for modelling the interactive element of choice between transporters and shippers. However, such approach demands an extensive dataset. Considering that the population of companies in the Port of Ghent region mainly consists of freight shippers, the choice models applied in this research follow the conventional simplification to a single decision unit. This will be addressed in the survey chapter. In terms of policy relevance, a disaggregate approach for mode choice can be found in national freight models used in Norway, Sweden and Denmark (Ben-Akiva and de Jong, 2013).

Freight mode choice models are typically characterised by the modes, attributes and model structures used. A range of applications across the freight transport mode choice literature can be found using different sets of modes, selection of attributes and different choice model structures. However, particular dominantly used modes, attributes or model structures become visible when comparing different freight studies. The following sections will briefly highlight the dominantly used modes (section 2.2), attributes (section 2.3) and model structures (2.4) found in the literature. In doing so, only a selection of freight mode choice studies will be referenced to serve as examples. However, an overview of relevant found mode choice studies (up to the knowledge of the author) is provided in Table 1. Separate columns are used to indicate the modes included in the studies, the model structures and attributes used. Table 1 is included at the end of the chapter in section 2.6. It needs to be noted that the table lists studies only on disaggregate freight mode choice and that are published later than 1996 (with the exception of one). A starting point from the mid 90s onwards is argued due to model developments from that period onwards, going from binary/multinomial logit and binary probit to more complex choice models such as mixed logit in the early 00s. However, it needs to be recognised that the majority of freight studies are still dominantly applying the multinomial logit model (MNL).

The chapter ends with a reflection (section 2.7), which positions the quantitative mode choice component of the research in relation to the literature and highlights the gap in the literature which the research aims to address.

2.2 Dominantly used modes in the freight mode choice literature

The modes considered most widely across the majority of freight mode choice studies are road and rail. This can either be in a setting of competing modes as well as in terms of combining modes: intermodal or multimodal. Both intermodal and multimodal transports make use of (at least two) different modes for a shipment from origin to destination. The difference between the two concepts is attributed to the nature of who handles the goods or shipment. In practice, this boils down to the handling contracts. Definitions of intermodal transport highlight the use of the same loading unit (mostly a container), in which the goods are not being handled during transfers between modes (UN, 2001; Dienel, 2004; UNECE/EU/ITF, 2009). Definitions of multimodal transport highlight the use of at least two modes but emphasise upon the use of a single contract from origin to end-destination (UN, 1980; UNECE/EU/ITF, 2009).

Both intermodal or multimodal applications are found in the freight mode choice literature (Table 1, ID's: 2, 3, 4, 6, 7, 8, 11, 12, 16, 18, 19, 21, 22, 25, 27, 28, 31, 32). For example, Shinghal and Fowkes (2002) researched an Indian intermodal rail container service, which was added as an alternative in addition to the road mode and a rail-only mode. Two European freight mode choice studies are referenced as examples using a multimodal service as alternative amongst other in the literature. Bolis and Maggi (2003) looked into the Swiss/Italian Alpine corridor and Jiang et al. (1999) included an intermodal rail-road transportation alternative in their model using a large-scale French shipper's survey.

However, the rail and road modes are not the only modes considered across the disaggregate freight mode choice literature. Particular studies also consider the water-bound modes (Table 1, ID's: 2, 4, 5, 6, 9, 13, 14, 16, 17, 21, 28, 33): international sea transports (mostly port choice literature), short sea shipping or inland waterway transports. Freight mode choice studies including water-bound modes are more scarce compared to studies using the road and rail mode. An example can be found in the research of Feo-Valero et al. (2010a, 2010b). Their case-study is set in the South-West European area, in which the modes considered are road and intermodal short-sea-shipping (SSS) using a mixed logit model on Spanish stated preference (SP) data. The authors concluded that policies aiming at lowering the costs for

maritime shipments and increasing the costs for other modes would trigger a higher probability of choosing the maritime mode (Feo-Valero et al., 2010a; Feo et al., 2010b). Examples of mode choice studies incorporating the inland-water-bound option are the studies of de Jong (2004) and Beuthe and Bouffioux (2008). Interestingly, the study of Beuthe and Bouffioux (2008) is one of the few examples that use Belgian stated preferences (SP) data including multimodal inland waterways as a mode option. Furthermore, a mode choice model including inland waterways is part of the Strategic Flemish freight model (Significance et al., 2015).

The choice of the modes being considered depends on the regional context of the studies. Not all modes are always possible nor seem realistic as existing infrastructure might not allow access. The modes considered in this research are road, rail, inland waterways and short sea shipping. These are all plausible and available modes in the Port of Ghent region. The deep-sea shipping mode is not included as the accessibility to the Port of Ghent region via the lock infrastructure in Terneuzen currently allows accessibility only for vessels up to 80000 tons carrying capacity and with a maximum draught of 12.5 meters (Flemish Port Commission, 2018). In addition, the pipeline alternative which is also available in the Port of Ghent was not considered as these are used mostly between different companies within the Port of Ghent region.

2.3 Dominantly used attributes in the freight mode choice literature

The following paragraphs focus on the selection of attributes that are included in the freight mode choice literature. Table 1 lists all attributes found in the included studies. However, only the attributes which are most commonly found across the literature will be briefly highlighted. In addition, the discussion on the assumed linearity or non-linearity specifications in the coefficients of the attributes is addressed in the methodology and discussion chapters.

The choice of which attributes to include in freight SP studies is important. Amongst other variables, the attributes explain the probability of choosing a particular mode-alternative and from these variables policy-relevant measures can be derived. Many different attributes are taken into account across the literature. These range from transport cost, transport time, flexibility, the chance on a certain degree of loss and damage to the cargo while underway,

reliability of the service, safety, frequency of the service etc. Derived from Table 1, the dominantly used or reoccurring attributes across the listed freight studies are: transport cost, transport time, frequency of the service and reliability of the service. With regards to policy measures, the most included attributes are transport cost, transport time and reliability to derive the value of time (VOT) and value of reliability (VOR).

The inclusion of a **cost** element is a necessity if the purpose is to derive price elasticities or valuations of the other attributes, such as for example the VOT. This is because the valuation of the other attributes is expressed relative to the cost attribute. The cost attribute is found to be expressed in currency per ton, currency per ton-km, total tariff or fare price per shipment depending on the need of the study. The sign of the cost coefficient is expected to be negative, which is reported in all listed studies in Table 1, excluding Jiang et al. (1999) who do not include a cost attribute. A negative sign of a significant found cost coefficient implies that increasing cost levels have a negative effect on utility and therefore the probability of an alternative being chosen. Some studies report rather large cost coefficients, such as for example in the study of Fries et al. (2010) (-10.1), while others report lower cost coefficients as for example in de Jong et al. (2004b) (-0.0031). However, when interpreting and comparing different results across studies it is important to note the differences in measurement unit, type of data being used (as the given example of de Jong et al. (2004) makes use of both RP and SP data) and if any model specifications differ, for example non-linear specifications in the utility functions for the cost attribute (which is the case for the given example of Fries et al. (2010)). It is also important to note that not all studies include the same number of alternatives or consider the same attributes, nor use the same model structures. This explains the range of reported coefficients in the freight mode choice literature and needs to be taken into account when comparing coefficients of any attribute.

A transport **time** attribute is present in almost all studies across the literature (again excluding Jiang et al. (1999)) and conventionally included to calculate the value of time (VOT), which is a relevant policy measure as it can be used to inform policy decisions with regards to transport infrastructure (cost-benefit analysis) for example (de Jong, 2007). The widely cited paper of de Jong (2014b) and more recent paper by Jensen et al. (2018) provide an overview of VOT measures across the European literature. In the majority of studies, the transport time

attribute is expressed in terms of transit time from door-to-door either in units of days or hours. This implies that expected delays are included. Significant found coefficients with a negative sign are systematically reported, indicating that the probability of choosing a particular alternative goes down with increasing units of transport time.

The value of reliability (VOR) has been increasingly gaining more attention since the mid 2000s in the freight transport literature. In order to compute the VOR, an attribute expressing reliability has been increasingly included in studies. The **reliability** attribute has conventionally been expressed in percentage of deliveries arriving on time (de Jong et al, 2014). However, in more recent work of de Jong and contributors (de Jong et al., 2014) on the Dutch VOTVOR study as well as by Halse et al. (2012) (in Krüger et al. (2013)) on the Norwegian GUNVOR study, the reliability attribute has been approached from a different perspective. Reliability is expressed in terms of *"the standard deviation of the transport time distribution"* (Krüger et al., 2013, pp 17). The authors argue that it is rather simple to include the standard deviation of the transport time in the utility functions of models (de Jong et al., 2014). In addition, a reliability component has also been included in freight mode choice studies in the form of a punctuality attribute as in Bergantino et al. (2013), Bouri and Masiero (2014), Masiero and Hensher (2010, 2012) and Rudel (2005). Regardless of the measurement criterion that is used to assess reliability, reported findings in the literature indicate positive and significant coefficients across different models (as for example 0.037 reported by Beuthe and Bouffioux (2008)). This implies that an alternative which has a higher reliability value is more likely to be chosen. In contrast, the study of Danielis et al. (2005) reports a negative coefficient of -0.48. However, the attribute is expressed as a measurement of risk on delay. Therefore, a negative coefficient sign is as expected as the attribute has a negative formulation of reliability and indicates the unreliability.

Certain studies have also included a **loss and damage** attribute. These were either expressed in terms of avoidance of loss and damage to the cargo (Beuthe and Bouffioux, 2008; Maggi and Rudel, 2005) or as a certain risk percentage of loss and damage (Masiero and Hensher, 2011; Danielis et al., 2005; Garcia-Menendez and Martinez-Zarzoso, 2004). Studies using the first expression report positive and significant coefficients, suggesting increasing probabilities of choosing an alternative with increasing percentages of avoiding loss and damage. Studies

using the latter report negative and significant coefficients which imply decreasing probabilities of choosing an alternative with increasing risk levels of loss and damage.

Based on Table 1, a variety of other attributes that are included across studies can be noted. These range from: flexibility and frequency (for example in Bollis and Maggi (2003) who define those as attributes related to logistic decisions), to inter-modality (as in Danielis and Marcucci (2007)), to company size (as in Jiang et al. (1999) or safety (as in Norojono and Young (2003)). The reader is referred to Table 1 for the full overview across all listed studies.

A crucial question for any study is to determine which attributes are of interest to include and which are not. On the one hand, the choice model needs to address the research interests. On the other hand, it is desirable that the model can be representative and relevant.

It was opted to include the three dominantly used attributes across the literature in this research, namely: transport cost (tariff), transport time and reliability. In doing so, the policy-relevant VOT and VOR measures can be derived. In addition, a loss and damage attribute was included as informal conversations with Port of Ghent staff indicated that the attribute could potentially be relevant in the case study area. In addition, the inclusion of a loss and damage attribute is also found in the studies of Ben-Akiva et al. (2008), Beuthe and Bouffioux (2008), Bergantino et al. (2013), Danielis and Marcucci (2007), de Jong et al. (2004), Evers et al. (1996), Marcucci and Scaccia (2004), Masiero and Hensher (2012), Rudel (2005) and Winston (1981).

Lastly, an environmental attribute was included as the research interest lies upon gaining insight on the impact of an environmental attribute on the preferences of the logistic managers as well as deriving a willingness to pay measure to the environment. However, examples from the freight mode choice literature including direct environmental attributes are scarce. If an environmental attribute is interpreted indirectly, the inclusion of such might be found in the study of Garcia-Menendez and Martinez-Zarzoso (2004). The study focusses on mode choice between road and shipping in Spain. The authors include a road-restrictive attribute which is in the context of environmentally-driven policy restrictions. The attribute is expressed in hours per year and is found small but significant in relation to the sea mode. A direct environmental attribute can be found in the work of Nugroho et al. (2016), however only applying on the inland mode choice as the authors both assess port and inland mode

choice. The GHG attribute is found significant and of negative sign, indicating that increasing levels of emissions have a negative effect on the utilities. Unfortunately, the study does not report on willingness to pay measures. In contrast, Nikolaus Fries and contributors (Fries et al., 2009 and Fries et al., 2010) reported and discussed a willingness to pay measure of freight shipper's with regards to the environment. The authors expressed the environmental attribute in terms of absolute percentage-changes in greenhouse gas (GHG) emissions and report on significant negative found coefficients (-0.46 in Fries et al. (2009)) and -0.45 in Fries et al. (2010)). The small difference between the two reported values is most probably related to the difference in the attributes included between the two models listed in the studies. These findings indicate that the likelihood of choosing an alternative is lower for more polluting alternatives. Up to the knowledge of the author, no other examples in the disaggregate freight mode choice literature are available. As the aim of the research is to derive a willingness to pay measure for the environment, the work of Fries et al. (2009, 2010) will therefore serve as a benchmark for the environmental impact assessed in this research. In addition to the environmental attribute, also environmental attitudes of freight shippers are taken into account to assess the impact on mode choice. However, up to the knowledge of the researcher, no previous freight mode choice studies were found that take into account such environmental attitudes.

The next section shifts the focus to the model structures of freight mode choice models and their recent developments in literature.

2.4 Dominantly used models in the freight mode choice literature

In addition to modes and attributes, a freight mode choice study can also be characterised by the type of model structures that are applied. The different model structures commonly found in the literature will be listed in the following paragraphs. For an in-depth description of the different models, the reader is referred to the Methodology chapter.

Almost all freight mode choice models found in the disaggregate behavioural demand freight literature are based on Random Utility Maximization (RUM). RUM is the theoretical framework which assumes that an agent maximises his or her utility. The word "random" in RUM refers to the aspects of utility which are not observable by the researcher (Train, 2009).

A look-back of over 30 years RUM in discrete choice modelling can be found in the paper of McFadden (2000). In the context of freight, the use of the RUM framework was emphasised by Winston (1979, 1981).

Prior and during the 90s, the most commonly found model is the **multinomial logit** model. It is still very popular and found in the majority of studies, either as main model or as a benchmark model to compare results derived from more complex model against. However, it can be noted that with increased model developments in the passenger discrete choice modelling literature, a gradual shift was noticeable towards more complex models such as the nested logit and during the 2000s towards latent class and mixed logit models.

A first example of a study moving away from the conventional MNL in the freight mode choice transport literature can be found in the work of Jiang et al. (1999). The authors estimated a **nested logit** structure on private and public transport modes on French revealed preference data. The public transport modes form a nest consisting of rail, road and combined rail/road. A nest indicates that the alternatives that belong to it form better substitutes for one and another. By public transport modes, the authors refer to transport that is outsourced by the companies to out-of-house transportation facilities. An interaction with distance is found, for which the authors report a tipping point of 700km for choosing public road transport and 1300km for public rail transport (Jiang et al., 1999). As DCM models in passenger literature developed further incorporating taste heterogeneity and thus relaxing the restrictive assumptions of MNL, **mixed logit** models started to appear more frequently since 2010 in the freight mode choice literature (for example in the studies of Arencibia et al. (2015), Feo-Valero et al. (2010) and Masiero and Hensher (2010) to name a few). The example highlighted is the paper of Fries et al. (2010), which applies a mixed multinomial logit structure and reports on random taste heterogeneity in the transport cost, time, reliability and GHG emissions attributes (using Normal distributions for the random parameters). Based on the model results, the authors continue to test different commodity-specific models to gain further insight on the taste heterogeneity and derive product-specific WTPs. Interestingly, the lowest WTP (CHF/tonne-km) for a reduction per percentage-point decrease in GHG emissions is noted for the iron and metal products, whereas the highest is noted for the manufactured goods. Arunotayanun and Polak (2011) emphasise taste heterogeneity in an Indonesian

freight mode choice application. Not only did they incorporate observed taste heterogeneity based on different commodity types (market segmentation), but they also employed **latent class** techniques to account for the unobserved taste heterogeneity based on classes derived directly from the data itself (endogenous segmentation). In doing so, the authors found taste heterogeneity beyond the conventional market segregation approach. Put differently, they have put the established and conventionally used method of applying market segmentation based on commodity type to address taste heterogeneity under scrutiny (Arunotayanun and Polak, 2011). Another example in the literature which applies a latent class choice model is the work of Brooks et al. (2012) on Australian shipper's stated preferences data. However, they concluded that the latent class framework was not fully effective to distinguish different classes from the data. However, it should be noted that mode choice models applying latent class modelling are still scarce in the freight mode choice literature in comparison with passenger literature (for example see Hess et al., 2011). This could be related to the more extensive data requirements in terms of observations needed to allow for latent class modelling and the issue of gaining access in general to large freight datasets.

Up to the knowledge of the researcher, only two freight studies are found to apply a **hybrid choice model**, which is a model framework that extends the choice model to include latent variables such as attitudes and other psycho-metric constructs (Ben-Akiva et al., 2002). This will be addressed in the methodology chapter as a hybrid model framework is applied in this research to assess the impact of environmental attitudes on mode choice. An example in the literature can be found in the work of Ben-Akiva, Bolduc and Park (2008), who focus on service quality. Another example is the study of Bergantino et al. (2013) who use a hybrid framework to address attitudes with regards to importance of attributes as perceived by freight operators in Italy.

All the paragraphs above on model developments in freight mode choice are based on models that use the RUM theoretical framework. In contrast, the use of an alternative framework can be found in the study of Bouri and Masiero (2014). The authors compare models using the RUM to the alternative of Random Regret Minimisation (RRM). RRM theory stresses that individuals tend to minimise their regret and has known increasing popularity in passenger transport studies as developed by Chorus and contributors (Chorus et al., 2008; Chorus et al.,

2010; Chorus, 2014). In sharp contrast to the passenger discrete choice literature, applying the RRM framework in a freight context has been significantly rarer. This makes the work of Bouri and Masiero (2014) a frontrunner in the freight field. The authors estimated mixed logit RUM and RRM models on Swiss stated preference data and found a slightly better model fit for the RRM based models. However, the authors nuance that the improvement in model fit arises more importantly with the negative shift that was created in the reference scenario (Bouri and Masiero, 2014).

Nevertheless, the RUM framework remains the dominant framework used in freight mode choice applications. It seems that freight applications are running a little behind and are only gradually catching up with more recent choice model developments when comparing them to choice models used in passenger applications. However, it can be argued that using discrete choice models to assess mode choice originated in the passenger transport literature and the difficulty in obtaining large and detailed freight data could also explain this discrepancy.

The underlying framework used to compute the choice models in this research is also that of RUM. Models such as the MNL, ML and hybrid choice model are clarified in the methodology chapter.

Across the freight mode choice literature, sensitivity analysis is often performed in the context of calculating elasticities. As listed in Tavasszy and de Jong (2013), the sensitivity analysis can be based on: distance, commodity type and sector, shipment size, company size and transport specifics. Examples of the interaction between the shipment size and mode choice can be found in the work of Combes (2010), de Jong and ben-Akiva (2007) or Abate and de Jong (2013). Abate and de Jong (2013) mainly focus on the road transport mode using Danish data. It was found that the shipment size increases with increasing distance and demand (Abate and de Jong, 2013). More recently, the study of Abate et al. (2018) integrates shipment size choice in a disaggregate freight transport chain model on Swedish data and finds that transport cost, transport time, rail or quay accessibility and distance are determining factors in mode and shipment size choice. To conclude, an example of the interaction of the transport distance (as well as the shipment weight) with mode choice using Swiss data can be found in the paper of

Masiero and Hensher (2011), in which the authors report a negative relation for long-distance transport.

2.5 Dominantly used data in the freight mode choice literature

Freight mode choice studies are also characterised by the type of data that is used. Two major types of data can be identified. On the one hand, stated preference (SP) data reflects stated behaviour by the respondent for choosing between hypothetical alternatives. It is argued that the main advantages of stated preference data are that it can include alternatives that do not yet exist, and it is relatively easier to collect in large quantities as it can include as many repeated choice tasks as determined by the researcher. However, the main disadvantage of SP data is that hypothetical choices do not necessarily translate into actual choices being made (Train, 2009). On the other hand, revealed preference (RP) data reflects actual choice behaviour. The main challenge -especially applicable to freight- is the difficulty and high associated costs in obtaining RP data. The French ECHO database is one of the few large RP freight transport databases available (Guilbault, 2008).

Both SP and RP sources of data can be combined. This is especially done in the context of using models to forecast. An example of a combined SP and RP freight study can be found in the work of de Jong et al. (2001). The authors estimated a joint model on data for French shippers following the method for combining SP and RP data as described in Bradley and Daly (1994). The study of de Jong et al. (2001) expanded existing RP data with SP data derived from a within-mode and between-mode stated preferences survey.

An important challenge for any researcher with regards to freight data, both SP and RP, is the lack of data and high degree of difficulty to obtain it. Various reasons have been put forward in the literature, but the overarching theme is on the nature of the freight data itself. Commercial interests and confidentiality are inherent to freight data (Tavasszy and de Jong, 2013; Jiang et al., 1999). Based on Table 1, it can be noted that stated preferences data is still the dominantly used data source in the listed freight mode choice applications (22 studies out of the 34 included).

The freight data obtained in this application is also stated preferences choice data. No revealed preference data was available for the regional case study of the Port of Ghent. This will be further addressed in the fourth chapter on the integrated survey and sample.

2.6. Overview table mode choice studies

Table 1 provides an overview list of relevant found literature up to the knowledge of the author.

The research is orientated in the disaggregate freight mode choice literature, therefore Table 1 only includes disaggregate mode choice studies and does not include aggregate modal split freight studies. In addition, it does not give an overview of national freight transport models which include mode choice components. The reader is referred to the work of de Jong et al. (2013), which lists an overview of (European) national freight transport models.

In the table, the following abbreviations used refer to: MNL to multinomial logit, ML to mixed logit, NL to nested logit, SP to stated preferences data, RP to revealed preferences data and EU to the European region.

Table 1: overview table freight mode choice literature

ID	Reference	Region	Data
1	Arunotayanun and Polak (2011)	Asia: Indonesia	SP
2	Arencibia et al. (2015)	EU: Spain - BENELUX/GR	SP
3	Ben-Akiva, M., Bolduc, D. and Park, J.Q.(2008)	USA	RP/SP
4	Beuthe and Bouffioux (2008)	EU: Belgium	SP
5	Bergantino and Bolis (2008)	EU: Italy	SP
6	Bergantino et al. (2013)	Italy	RP/SP
7	Boeri and Masiero (2014)	EU: Switzerland	SP
8	Bolis and Maggi (2003)	EU: Switzerland/italy (Alp corridor)	SP
9	Brooks et al. (2012)	Australia	SP
10	Chiara et al. (2008)	EU: Italy-France	SP
11	Danielis et al. (2005)	EU: Italy	ACA SP
12	Danielis and Marcucci (2007)	EU: Italy	SP
13	de Jong et al. (2001)	EU: France	SP/RP
14	de Jong et al. (2004)	EU: Netherlands	SP/RP
15	Evers et al. (1996)	Usa	other
16	Feo-Valero et al. (2011b)	EU: Spain	SP
17	Feo-Valero et al. (2011a)	EU: SPain	SP
18	Fries et al. (2009)	EU: Switzerland	SP
19	Fries et al. (2010)	EU: Switzerland	SP
20	Garcia-Menendez and Martinez-Zarzoso (2004)	EU: Spain	other
21	Jensen et al. (2018)	EU	RP
22	Jiang et al. (1999)	EU: France	RP
23	Ki-Chan Nam (1997)	Asia: Korea	RP
24	Kurri et al. (2000)	Finland	SP
25	Marcucci and Scaccia (2004)	EU: Italy	SP
26	Masiero and Hensher (2012)	EU: Switzerland	sp
27	Masiero and Hensher (2010)	EU: Switzerland	SP
28	Nugroho et al. (2016)	Asia: Indonesia	SP
29	Norojono and Young (2003)	Asia: Java (Indonesia)	SP
30	Nijkamp et al. (2003)	EU	RP
31	Rudel (2005)	EU: Switzerland	SP
32	Shinghal and Fowkes (2002)	Asia: India	SP
33	Vellay and de Jong (2003)	EU: France	SP/RP
34	Winston (1981)	USA	Commodity Survey

Table 1: continued

ID	Model	Time	Cost	Reliability	Frequency	Flexibility
1	ML	X	X			X
2	ML	X	X	X (delay)	X	
3	hybrid	X	X	X		X(latent)
4	rank ordered logit	X	X	X	X	X
5	Tobit ML estimator	X	X	X	X	
6	hybrid	X	X	X (punctuality)	X	
7	ML	X	X	X (punctuality)		
8	log regression	X	X	X	X	X
9	Latent Class	X	X	X	X	
10	MNL	X			X	
11	Probit	X	X	X		
12	MNL/Random Parameter Logit	X	X	X (late arrivals)	X	X
13	MNL	X	X	X	X	X
14	MNL/ML	X	X	X	X	
15	log regression	X	X	X	X	
16	ML	X	X	X	X	
17	ML	X	X	X	X	
18	ML	X	X	X		
19	ML	X	X	X		
20	MNL	X	X		X	
21	ML	X	X			
22	Nested Logit				X	
23	MNL	X	X		X	
24	MNL	X	X	X		
25	MNL	X	X	X	X	X
26	MMNL	X	X	X (punctuality)		
27	ML	X	X	X (punctuality)		
28	ML(: MMNL & mixed Nested logit)	X	X	X		
29	Nested Logit	X	X	X	X	X
30	MNL	X	X			
31	MNL	X	X	X (punctuality)	X	
32	MNL	X	X	X	X	
33	MNL	X	X	X	X	X
34	probit	X	X			

Table 1: continued

ID	Loss & Damage	Shipment Size	Distance	Environment
1				
2				
3	X	X	X	
4	X			
5				
6	X	X(load factor)		
7				
8				
9			X	
10				
11				
12	X			
13				
14	X			
15	X			
16				
17				
18			X	X (GHG)
19				X (GHG)
20				X (road restriction)
21				
22		X	X	
23		X (weight)		
24				
25	X			
26	X	X (weight)	X	
27				
28				X (GHG)
29				
30				
31	X			
32				
33				
34	X	X		

Table 1: continued

ID	SPECIFIC CHARACTERISTICS OF GOODS	OTHER
1	X (cargo value)	
2		
3		X (latent: familiarity & riskiness)
4		
5		
6		X (company size)
7		
8		
9		
10		
11		X (safety)
12		X(inter-modality)
13		
14		
15		X (availability)
16		
17		
18	X	X (inter-modality)
19		
20		
21		
22	X	X (company size)
23		
24		
25		
26		
27		
28		
29		X (quality and safety)
30		
31		
32		
33	X	
34		X (availability & refrigeration)

2.7. Reflection

The research component that focusses on quantitatively assessing mode choice is in line with previous disaggregate literature on mode choice by applying choice modelling techniques to assess the impact of key-identified attributes in the literature. These are: transport time, transport cost, reliability and loss and damage. However, considering the policy background of European objectives directed at reducing GHG emissions from transport and aiming at a modal shift away from the road mode, the emphasis of this research is on the impact on mode choice of on the one hand, an environmental attribute and on the other hand, environmental attitudes.

It could be noted that only two applications included a direct measure of the environment in the form of GHG emissions, namely Fries et. al (2009, 2010) and Nugroho et al. (2016). However, only Fries et al. (2009,2010) report on a WTP measure as Nugroho only includes an environmental attribute for the inland mode choice as the objective is the combination of port choice and inland mode choice. The application follows the line set by the references by focussing on emissions, however, the phrasing of the attribute differs. This is discussed in the chapter on the survey (section 4.4.2). The application aims to add a willingness to pay measures for the environment to the freight mode choice literature by applying a multinomial logit model and mixed multinomial logit model allowing for random taste heterogeneity.

In addition to an environmental attribute, environmental attitudes are included in the application to address the impact of these on mode choice. This implies the use of a hybrid model, which are very scarcely found in the freight model literature. Two examples were referenced, namely Ben-Akiva et al. (2008) and Bergantino et al. (2013). However, both studies did not elaborate upon environmental attitudes. To the best of the researcher's knowledge, this application is the first to employ a hybrid choice model to account for underlying environmental attitudes of freight shippers in their mode choices. Specifically, an integrated choice and latent variable model (ICLV) is applied. This is discussed in the next chapter: Methodology (section 3.4.3).

Lastly, a qualitative component is added to the quantitative mode choice component to gain understanding of the contextual setting in which mode choices are taken in practice. It could be noted that the referenced studies in Table 1 did not report on qualitative insights related to mode choice. This will be discussed in the methodology chapter in which the mixed methods research design is highlighted. Furthermore, the qualitative identified factors are integrated in a choice model by applying an ICLV framework of which the preliminary results are included in results chapter two (section 5.2.5).

3. Methodology

3.1. Introduction

Understanding what impacts freight shipper's transport mode choices and in which company contextual setting they are made forms the motivation for this research. The modal split is the outcome of a large number of freight mode choices made in the transport market. From a policy perspective, where measures are taken to shift freight transport towards more sustainable modes, it is interesting to gain insights into the triggers of change of such a shift as perceived by the decision-makers (here limited to shippers only in the context of the Port of Ghent). Especially as freight choices are complex (as they mostly involve multiple actors and a variety of goods as is argued in the freight transport literature, see chapter two) and underpinned by their economic and specific corporate nature, the methodological framework of mixed methods is put forward as fitting to address this complexity. It offers both the benefit of understanding the quantitative impact of key-variables on freight mode choice, as well as gaining deeper insights in the underlying corporate context and perceived interests with regards to the topic of a freight modal shift specifically related to the case-study area.

This methodology chapter is structured according to the different techniques selected to address the different research questions as described in the introduction chapter. These are clustered around three main topics: freight mode choice, contextual setting of freight mode choice added with the validation of SP choices and a freight modal shift towards more sustainable modes.

The next section (3.2) will discuss the overarching methodological umbrella of mixed methods (MM). Put simply, the mixed methods methodology comes down to the integration of at least one qualitative technique with at least one quantitative technique in a single study. The emphasis is on the word "integration", which can take place at multiple phases of the research process: data collection, data analysis and interpretation. It is argued that applying mixed methods has the advantage of incorporating both insights from qualitative as well as quantitative findings. The specific MM design followed in this research is that of a convergent

design. However, merely combining a qualitative method and a quantitative method without integration at any of the research stages comes down to multi-methods and not mixed methods (Creswell et al., 2011). It is argued that integration in this research takes place at the three identified research stages (data collection, analysis and interpretation).

Section 3.3 will focus on the main quantitative method used, namely that of discrete choice modelling. The three model structures applied are discussed. The multinomial logit (MNL) and mixed multinomial logit with random taste heterogeneity (MMNL) are used to address the impact of time, transport cost (tariff), loss and damage, reliability and CO_2 emissions on freight mode choice. In addition, an integrated choice and latent variable (ICLV) model is put forward to assess the impact of environmental attitudes, both specified on the individual level as well as the corporate level, on freight mode choice. Whereas the MNL and MMNL only make use of the collected choice data (stated preferences), the ICLV also makes use of the collected attitudinal data.

Section 3.4 gives an overview of the qualitative method of thematic analysis (TA) in which node coding was applied upon transcribed semi-structured open-ended interviews using Nvivo software. The iterative node coding process and analysis of the node structure resulted in the emergence of different themes, which can be regarded as the main output of the qualitative analysis.

Section 3.5 will highlight the exploration of MM integration that took place at the modelling stage (analysis research phase). Integration took the form of incorporating the qualitatively derived themes into a choice model framework. In doing so, the ICLV choice model framework was put forward to include additional latent variables to capture the themes. However, it needs to be stressed that the integration of qualitatively derived themes into a choice model framework is of an explorative nature and has only been tested here to a basic extent. Future model trials and other transformations are recommended for future research.

Lastly, the methodology chapter ends with a reflection on the discussed methods.

3.2. Mixed Methods

Freight shipper's mode choices can be understood as complex decisions to which the corporate and economic nature cannot be overlooked. The individual does not merely make a mode choice for his or her own transportation, such as choosing between a bike to ride to work or taking the car, but makes a mode choice on behalf of the corporate organisation where he or she is employed. Therefore, the need to understand the perceived corporate context by the decision-maker when assessing freight mode choices arises. A Mixed Methods (MM) approach is proposed to gain understanding in freight shipper's mode choices in this perceived context. The study can be categorised as a convergent MM design with quantitative priority.

The following sections will briefly describe the emergence of the MM field and will propose a justification for the use of the framework. The next section (3.2.1) will get into the specific MM design and concept of integration, followed by section 3.2.2 which will give an overview of the different techniques used to address the research questions. This forms the bridge to the following sections (3.3, 3.4 and 3.5), in which the separate techniques are elaborated upon. Firstly, the quantitative technique of choice modelling will be discussed as the MM design is one of quantitative dominancy (section 3.3). Secondly, the qualitative method of thematic analysis will be highlighted (section 3.4) and lastly, an exploration towards a mixed model will be given (section 3.5).

The methodological field of mixed methods has been developing since the 1980s and has continued to grow through the 2000s (Creswell and Clark, 2011). Mixed methods (MM) in its most simple definition can be understood as combining both a qualitative technique with a quantitative technique leading to an integrated research design for a single study (Bergman, 2008). The emphasis lies on the word "integration", as it is not simply multi-method research. The latter is merely the collection of multiple forms of a data, where no integration of qualitative and quantitative data in the analysis nor interpretation phase takes place (Creswell, 2015). MM breaks with the widely used conventional distinction within research methodology. Namely, employing solely quantitative methods or having a positivist approach versus employing solely qualitative methods and thus having a more constructivist approach

(Bergman, 2008). However, over the years and across fields a wide variety of definitions of mixed methods research have circulated, which has led to a certain degree of ambiguity. One of its founding fathers Creswell (2015) argues that this is because of the various philosophical or methodological perspectives the researchers can take when conducting mixed methods research. It needs to be clarified at this point that for this application a pragmatic approach is followed for both the ontological and epistemological viewpoints, following the MM-line of Creswell. This implies that the underlying debate on what knowledge is and how to interpret it is pushed to the background. It will only briefly be addressed in the text when justifying the use of the MM framework. An overview of the development of the definition of mixed methods can be consulted in the work of key authors Bergman (2008), Creswell and Clark (2011) and Tashakkori and Creswell (2007), whereas a list of the various definitions that are circulating can be found in the paper of Johnson et al. (2007). For clarity, the definition that appeared in the first edition of the Journal of Mixed Methods Research will be followed in this research. This is in line with the work of Tashakkori and Creswell (2007), who argue for a single one-fits-all definition:

> *"research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry." (Tashakkori and Creswell, 2007b, p.4 in Creswell and Clark, 2011, p4).*

Applications of mixed methods can be found mostly in the health sciences, educational sciences, management sciences and social sciences (Creswell and Clark, 2011). It needs to be noted that MM is an emerging methodological trend that is still gaining momentum through the 00s, but acceptance in the academic community of its use is not always straightforward. For example, in the business and management literature, the study of Cameron and Molina-Azorin (2011) finds that only 14% of the studies in their literature sample consisted of using mixed methods. However, counter arguments for the validity or added value of using MM in the (international) business research are given by Hurmerinta-Peltomäki and Nummela (2006). Yet, with regard to the freight transportation literature the use of mixed methods as a methodological framework (as followed by the definition given above) is not yet established.

It is interesting at this point to get an idea of the current knowledge-base with regards to using MM in freight transportation research (especially mode choice). To assess this at a primary surface level, the popular databases of Web of Science and Scopus were used. The initial search based on the keywords “freight transport” combined with “mixed methods” triggered one result in the Web of Science search and two result in the Scopus search.

The paper of Eng-Larsson and Norrman (2014) is indeed a mixed methods study in the sense that it combines and integrates both QL and QN techniques and findings in the same study. In particular, they look at the role of contracts in intermodal transport markets with two case-studies on an existing carrier and intermodal rail operator. However, the second study listed in the Scopus search did not consist of a mixed methods application, as it purely made use of quantitative techniques (Trofimenko et al., 2018). The particular research interest in this research is on freight mode choice. However, the key-word search based on “freight mode choice” combined with “mixed methods” did not trigger any hits. Neither in the Web of Science database, nor the Scopus database. Out of curiosity, the search with key-words “mode choice” and “mixed methods” triggered three results in the Web of Science search and four in the Scopus search. All studies were passenger transport applications making use of MM.

Not triggering any search results for “freight mode choice” and “mixed methods” making use of such popular databases does not imply that all freight mode choice studies in the literature make therefore solely use of qualitative techniques or quantitative techniques. The work of Fowkes et al. (1991) on intermodal rail freight transportation serves as a good example of a study in the freight transportation literature. The study combines both qualitative and quantitative data. Nevertheless, it is clearly quantitatively orientated using the LASP (Leeds Adaptive Stated Preference) survey method combined with a cost model to asses inter-modal services in the context of the Channel tunnel for the UK. Yet, it does also mention -using the phrasing of the authors- the collection of “*qualitative information*” and “*qualitative assessment*” with regards to quality of the service. Fowkes et al. (1991) utilise these to provide potential indications to why the quantitative findings did not result as expected, for example for the results with regards to beer producers. However, it can be debated upon if the study would now be categorised as either multi-method or mixed methods. As the nuance in the standard definition of MM is on the word integration, it could be argued here that the study

would be labelled as MM as some integration takes place at the interpretation phase. However, it can also be argued that the study falls under multi-methods as the qualitative findings are only utilised if quantitative findings did not result as expected and no single standing qualitative or mixed insights were reported. In addition, the authors do not expand upon the method they applied to analyse the qualitative findings, nor report on separate qualitative findings. Considering these, it remains debatable whether the MM label is in place. In addition, the use of qualitative interviews and/or focus groups prior to inform a quantitative survey is not a new practise in the freight transport literature. For example, the study of Beuthe et al. (2003) is of particularly interest as it deals with Belgian shippers in which preliminary in-depth face-to-face interviews were conducted to gain additional information. Again, it can be argued that this falls under a mixed methods approach. More recent, Beuthe and Bouffioux (2008) used face-to-face interviews to inform their final questionnaire with Belgian transport managers, assist the respondents during the reference scenario collection and get a degree of understanding of the acceptance to a modal shift. This acceptance of a modal shift was translated to a binary variable in terms of "change of mode or not" which served as a variable (amongst others such as distance, good value, loading unit, mode, goods category) to divide the sample to estimate sub-models. Therefore, it might be argued that this would fall under mixed methods, however, the integration approach is not described nor qualitative findings with regards to a modal shift are reported.

Scratching only the surface, it became visible that mixed methods as a methodological framework is not yet widely spread or established in the freight transport mode choice literature. However, it is argued for this research that the use of a mixed methods methodological framework is justified based on the following reasons.

Considering the type of choice in which a strong corporate contextual setting is present, it is argued that applying mixed methods can address both the research needs of understanding the impact of key variables on these freight mode choices ("how much") as well as understanding underlying motivations and the company context in which they are made ("how", "what" and "why"). Specific to each individual company, different organisational aspects, production characteristics and company objectives can be explored in relation to the mode choices made in practice. Relating to the decision-making in policy, potential perceived

triggers for a modal shift for the specific case-study area can be explored. A mixed design allows to cater for the heterogeneity in firms, while maintaining a standardisation at the same time. Put differently, applying mixed methods allows the researcher to cater for quantitatively orientated, qualitatively orientated and combined research questions.

Apart from the conventional freight mode choice research interest, a specific interest is on the role of the environment and the impact of environmental attitudes on freight mode choice decision-making and on a freight modal shift towards more sustainable modes. While the latter topic is not a new topic and has been widely studied in the freight literature or logistics literature, the approaches used have been dominantly quantitative with the calculation of market shares under the impact of policy measures (for example see the work of Blauwens et al., 2006). Adding to the literature, this study aims at deriving both insights from a conventionally used stated preferences approach in freight mode choice as well as in-depth qualitative interviews to derive insights into the characteristics and contextual setting as perceived by the logistical managers (identified as the decision-makers in this research). Incorporating an environmental aspect is not straightforward as strategic bias might be present (e.g. corporate interests with regards to trying to influence policy decision-making or a commercial interest to have a green public image). In addition, attitudes are interrelated with values and beliefs which lends themselves to a more in-depth understanding via qualitative interviews. Therefore, there seems to be scope for gaining from the advantages from both qualitative and quantitative methods.

Further, obtaining freight data is challenging due to the sensitive business nature. Considering the lack of major funding bodies to sponsor the survey and a limited total population of shipper companies in the selected case-study (100), it was expected to have difficulty to acquire a large dataset. In light of this, it is argued that by integrating a stated preference survey and qualitative interviews the information gained would be optimised.

Lastly and up to the author's knowledge, studies in the freight mode choice literature applying a convergent MM design have not yet been established and therefore this study can provide insights in terms of survey design and challenges encountered as well as give indications for

future freight SP studies. The different types of MM designs will be discussed in the next section 3.2.1.

Following upon the argumentation given for the use of a mixed methods methodological framework, a statement on the underlying paradigm that was followed needs to be made. Pragmatism as a paradigm is followed throughout the research, both for the ontological and epistemological viewpoint. The choice for this paradigm follows from the research questions and design, as the different type of research questions driving the research cannot be answered by one technique alone. This is in line with the school of thought of one of the founding fathers, namely Creswell (Creswell and Clark, 2011).

In spite of its advantages, mixed methods is not a methodological holy grail. While authors have been arguing that MM addresses both the shortcomings of qualitative research as well as quantitative research by combining the techniques, the mixed methods methodology has been heavily debated upon and is not without critique. One of the key identified issues is the high requirement in terms of the dataset. Both qualitative and quantitative data needs to be collected, which is intense in terms of time-consumption and requires skills of the researcher in both methods. In addition, it is not always easy to balance between quantitative and qualitative findings, even more so when they are contradictory (Bergman, 2008; Doyle et al., 2009; Creswell and Clark, 2011). Another challenge lies in the replication of MM studies, as these are often context or case-study dependent (Gerschewski et al., 2015).

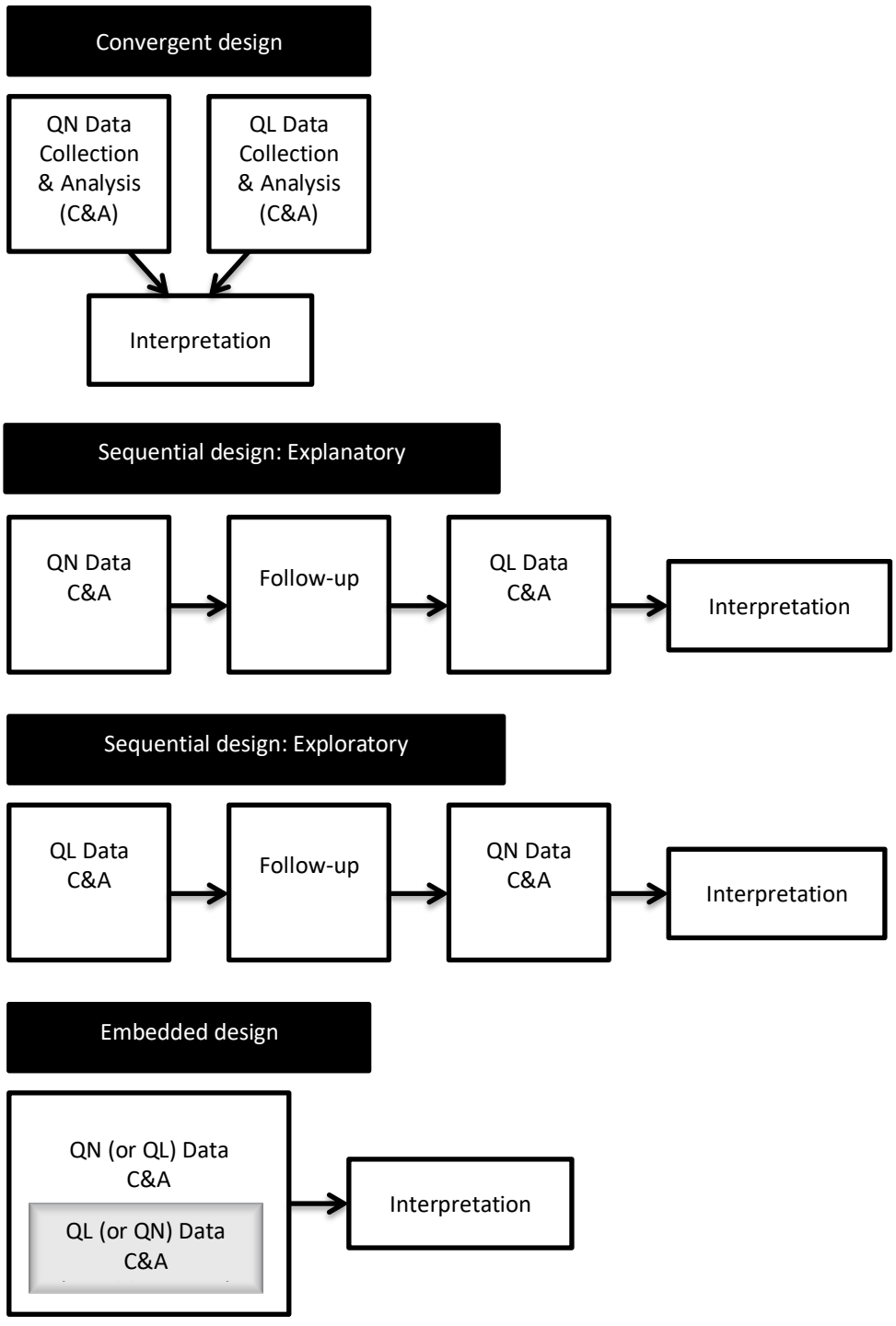
Now that a brief background has been given for mixed methods as well as the motivation for its use, the next section (3.2.1) will briefly introduce the different types of MM designs and will elaborate on the design followed in this research application.

3.2.1. MM design

In general, three main major types of design can be distinguished in mixed methods approaches (Figure 8). Firstly, **convergent designs** are designs in which quantitative and qualitative data are collected and mostly analysed separately to then merge the findings and conclusions of both methods for interpretation. It is important to emphasise that both methods are performed independently and simultaneously in terms of research timing (Bergman, 2008; Creswell and Clark, 2011) with integration generally taking place at the interpretation of the results (Creswell, 2015). For example, results from the quantitative analysis can be shown in the form of a discussion together with the results from the analysis of the qualitative data (or vice versa). Some applications apply joint displays, which graphically contain both quantitative and qualitative results. However, integration is not solely limited to taking place at the interpretation of results research phase. For example, the quantification of qualitative results (or vice versa) is also a popular integration practice to merge the two data-sets (Creswell, 2015). Secondly, **sequential designs** can be subdivided in explanatory designs and exploratory designs. On the one hand, in explanatory sequential designs a quantitative method is followed up by a qualitative method. The qualitative findings help to support or understand the initial quantitative findings. On the other hand, exploratory designs use a qualitative method to progress into a quantitative method. In this design the initial exploratory findings lead to a quantitative model which tests these findings. This design is conventionally implemented to construct an instrument or intervention measure (Creswell, 2015). It is particularly this type of design which could be argued to have been used in practise in the freight mode choice literature (see discussion above on Fowkes et al. (1991)). What centrally distinguishes sequential designs from convergent designs is the interaction element between the two methods. In addition, the divergence between convergent and sequential designs is marked by the timing of the two methods, as it is not simultaneous but sequential in the latter (Bergman, 2008; Creswell and Clark, 2011). Thirdly, **embedded designs** nest one method within another method. This can be a qualitative method within a quantitative method or the other way around. The timing of the nested method can differ according to research needs and experimental stage of the research. Parallel to sequential designs, the main difference of embedded designs with convergent designs is the interaction between the two methods (Bergman, 2008; Creswell and Clark, 2011).

More extensive typologies exist according to the research purpose, the level of interaction between the different methods, the order of the timing of the methods and the priority level of the methods (Creswell and Clark, 2011). For example, designs can differ according to the weight the researcher gives to the quantitative and the qualitative method. The researcher can give equal weights to both the methods or express a preference towards the quantitative method or qualitative method in addressing the research subject. This is known as equal priority, quantitative priority or qualitative priority (Creswell and Clark, 2011). A side-note needs to be made with regards to the typology. In his more recent work, Creswell (2015) classifies MM designs slightly differently compared to the typology put forward in the mixed methods reference work of Creswell and Clark (2011). Creswell (2015) emphasises three basic designs (convergent, explanatory sequential and exploratory sequential) and argues that these can be upgraded to more complex designs by adding design elements by which for example the design results in that of an embedded design.

Figure 8: Base typology of MM designs



Source: based on Creswell and Clark (2011)

The mixed methods design followed in this application consist of a convergent (also known as concurrent) design with quantitative priority. This type of design elegantly allows for addressing the research questions formulated on freight mode choice, as well as those formulated with regards to the perceived company context and freight modal shift. The design integrates stated preferences choice tasks with open-ended semi-structured interview questions. The design is represented visually in Figure 6. It shows that both qualitative and quantitative data were collected separately, but also simultaneously. Both types of data were collected for each respondent, thus not separating the individuals according to a specific type of data. Qualitative data was collected in the form of semi-structured open-ended interviews following an interview protocol (also known as interview guide or "script") and quantitative data was collected through a stated preference choice survey and attitudinal questionnaire. The red colour in Figure 6 indicates where integration took place in the research process, this will be elaborated upon in the next sections.

Conventionally, the main purpose of a convergent design is to link or complement results from both methods by letting integration take place in the interpretation of the results research phase (Creswell and Clark, 2011). In contrast, integration is argued here to be taking place in the three phases of the research process: namely at data collection, data analysis and interpretation.

During data collection, interaction between the stated preferences survey and qualitative interviews was actively sought, however, making sure not to steer the choices made during the SP. The reader is referred to the survey chapter for more detail on how influence on the SP choices was minimised. Interviewees were confronted only after the SP choice tasks with their comments made during the choice tasks to elaborate in-depth on their motivations, perceptions and experiences during the particular choice tasks. In addition, open-ended interview questions explored further on their experiences on the SP survey overall and their perceptions with regards to the *"realism*" of the survey (the resemblance to mode choice making in practise). Considering this interaction, it is argued that integration of quantitative and qualitative components takes place at the collection phase.

During the data analysis research phase, integration took place after separate analysis. First each type of data was analysed separately using their corresponding methods to derive insights. Next, integration took the form of quantifying particular qualitative findings to introduce them into an extended choice model using an integrated choice and latent variable (ICLV) model framework. This was done to exploratively assess the potential impact of the derived qualitative themes on freight mode choice.

Lastly, as in all mixed methods design, integrating different findings at the interpretation of result research phase took place by comparing the findings side-by-side to strengthen or nuance one and another.

Figure 6: MM research design: convergent

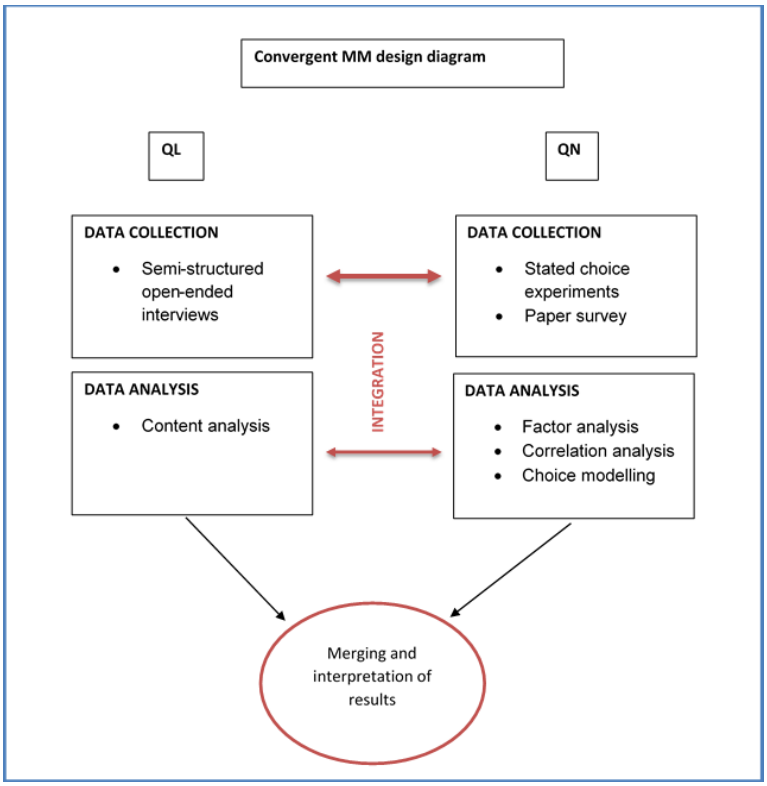
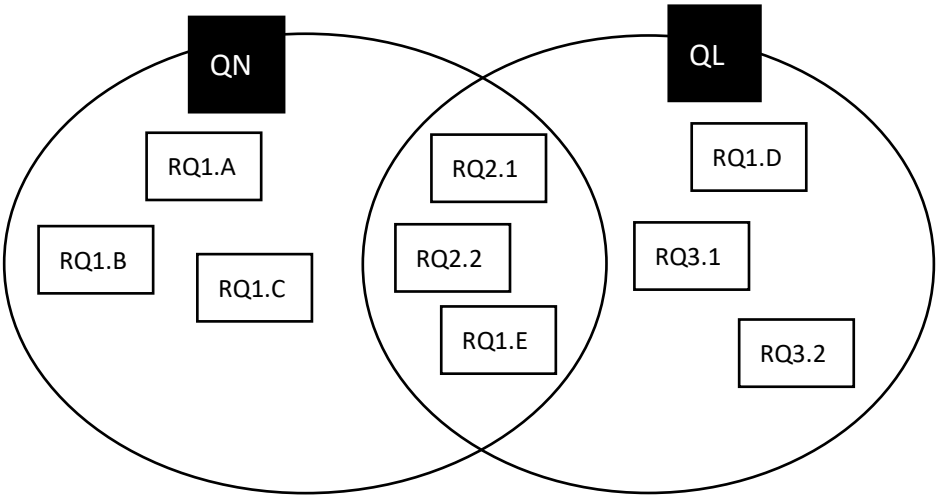


Table 2 provides an overview of the different methods of analysis or techniques applied, as well as the software used per type of data collected and analysed. In addition, Figure 4 shows a diagram which positions the different research questions according to the techniques used.

Table 2: summarising table per type of data

	Data collection method	Analysis Tool	Software
QL	Open-ended interview questions	Thematic analysis	Nvivo
QN	Stated choice survey	Discrete choice modelling	Ngene (design), R (modelling)
	Paper survey: attitudes	Factor Analysis/Alternative	Stata/R

Figure 4: Positioning research questions



The main quantitative method of choice modelling, as well as qualitative method of thematic analysis will each be discussed separately in the following sections. As the MM design is that of a convergent design with quantitative priority, choice modelling will be elaborated upon first and more extensively with regards to the specific model structures applied. Secondly, the qualitative method of thematic analysis making use of node coding in Nvivo will be described.

3.3. QN: Choice Modelling

Train (2009) traces the origins of the field of choice modelling back to the 1920s with Thurstone (1927) and to the 1960s with for example Marschak (1960). The field has been evolving strongly since the 1970s with the establishment of the logit formula which was completed by McFadden (1974) for which he received the Nobel prize (Train, 2009). At the centre of choice modelling is analysing choice behaviour, mostly for the purpose of valuation (and appraisal) and/or demand forecasting. A historic overview of the development of the field can be consulted in the Nobel Prize lecture of Daniel McFadden, in which he elaborates on the logit formula and positions the field in relation to previous micro-economic consumer theory. He highlights the different developments in the field with regards to model structure complexity parallel to data availability and computational advancement (McFadden, 2001).

Choice modelling is widely applied to explain and forecast various choices across different fields: ranging from transport, health sciences, environmental economics to marketing and consumer applications. A thorough overview specifically to the transport literature can be found in the paper of McFadden (2000), which provides a look-back over 30 years of random utility maximization (RUM)-based DCM on disaggregate behavioural travel demand. The RUM framework assumes that a decision-maker maximises his or her utility derived from an alternative (i.e. the decision-rule). Put differently, as in many neo-classical economic models it assumes rational behaviour of the agent. The random (utility) approach is in sharp contrast to a deterministic (utility) approach of choice behaviour by allowing for a random or stochastic component (unobserved). In a deterministic choice framework, the alternative is necessarily chosen for which the utility is highest. However, in the RUM approach the probability of choosing an alternative is analysed. Across the choice modelling literature, RUM remains the dominantly used framework. However, alternative frameworks such as random regret minimisation (RRM) for example have been developed. The individual is assumed to minimise his or her regret, rather than optimising his or her utility he or she gets from an alternative (e.g.. Chorus et al., 2008, Chorus et al., 2010, Chorus, 2014). Specific to this research application, it is argued to stay within the RUM framework as it is well established and conventionally done in the freight mode choice literature (Tavasszy and de Jong, 2013).

Therefore, the following model structures included will be based on the principles of random utility maximisation only and no alternative heuristic frameworks.

A standard choice model is characterised by a utility function $U_{n,i,t}$, which described the utility of an alternative (i) per respondent (n) in choice task (t). It is characterised by including a deterministic component $V_{n,i,t}$ and random (or unobserved) component $\varepsilon_{n,i,t}$:

$$U_{n,i,t} = V_{n,i,t} + \varepsilon_{n,i,t} \qquad (1)$$

With n = respondent
i = alternative
t = choice task

$$V_{n,i,t} = f(\beta, x_{n,i,t}, s_n) \qquad (2)$$

$V_{n,i,t}$ is a function of the attributes of the alternative ($x_{n,i,t}$) and taste model parameters (β). It can also include socio-demographic variables of the respondent (s_n). This function can be assumed linear but can also be specified non-linear depending on the specifications chosen by the researcher. The $\varepsilon_{n,i,t}$ represents the error terms (random component). Assuming utility maximization, the decision-maker choses the alternative with the highest utility for which the probability of choosing an alternative is estimated (Hensher et al., 2005; Train, 2009).

Regardless of the model structure considered, each choice model consists of decision-makers choosing from a choice-set of alternatives. Upon these choices made, the choice probabilities are computed, and the parameters are estimated. The decision-maker can be an individual, a company, a household, the government or even an animal such as a bear (presented by Marek Giergiczny at ICMC 2017, Griegiczny and Hess (2017)). In this research application, the decision-maker is reduced to the logistical manager of the firm, which is consistent with freight transport mode choice literature (Tavasszy and de Jong, 2013). However, the strong simplification in doing so is recognised, as interactive multi-stakeholder surveys are also found in the literature (see survey chapter 4). It is important to note that for discrete choice models, the choice-set of alternatives is assumed to be mutually exclusive, exhaustive and finite (Train, 2009). In other words, the decision-maker can only choose one alternative at a time from a countable set which includes all relevant alternatives. The choice-set considered for the different models in this application includes three unlabelled alternatives (transport 1, 2 and

3) in the first SP experiment and four labelled alternatives (road, rail, inland waterways and short sea shipping) in the second.

Three main model structures are used in this application, namely: the multinomial logit (MNL), mixed multinomial logit with random taste heterogeneity (MMNL) and hybrid-MNL. Each model is discussed separately in the following sections (3.3.1 – 3.3.3).

3.3.1. Multinomial Logit Model (MNL)

The multinomial logit model (MNL) has been widely used across the DCM literature as the standard choice model, however, it is also the most restrictive model within the GEV family. The word restrictive refers to the assumptions that are placed upon the error component. It assumes that the error terms $\varepsilon_{n,i,t}$ are independent and identically distributed (iid extreme value type 1). The assumption implies that the error terms are not correlated across alternatives. An important implication of this assumption is that the integral over the density of the error terms has a closed form.

These criteria result in the following choice probabilities of alternative i relative to alternative j for repeated choices (4), for mathematical proof of this formula [(3) to (4)] the reader is referred to Hensher et al. (2005) or Train (2009):

$$P_{n,i,t} = P\left(V_{n,i,t} + \varepsilon_{n,i,t} > V_{n,j,t} + \varepsilon_{n,j,t}\ \forall j \neq i\right) \quad (3)$$

=>

$$P_{n,i,t} = \frac{e^{V_{n,i,t}}}{\sum_j e^{V_{n,j,t}}} \quad (4)$$

Important to note is that the choice probabilities take a value between zero and one and the sum of all choice probabilities (i.e. for all alternatives) is one. Specifically, the IIA or independence from irrelevant alternatives condition applies (resulting out of $\varepsilon_{n,i,t}$ ~iid). This implies that a given ratio of the choice probabilities of two alternatives does not depend on any other available alternatives as the denominators cancel each other out (Train, 2009). Intuitively, the ratio of the choice probabilities of a train relative to a ship do not depend on a truck alternative which would be available. In the literature, this is often referred to as the

"*red-bus-blue-bus*" issue. In addition, it is important to note that under the IIA assumption the substitution pattern is that of "*proportionate shifting"*. This indicates that the substitution caused by a change in one of the alternatives is spread proportionally across all the other alternatives (referral to Train, 2009). Relating back to the given example and adding another alternative. Imagine the price goes up for the train alternative. The train would become less attractive and the likelihood of choosing it would go down, for which the probability of choosing the inland waterway ship, short sea ship and truck would increase proportionally. However, this might be unrealistic as for example an unobserved factor such as a dislike of logistics managers towards on -and offloading efforts with specific requirements could be similar for the rail and waterborne vessels, but not for the truck as trucks might be perceived easier in terms of on -and offloading requirements. This would indicate that there is correlation between the unobserved factors of disliking on -and offloading efforts with specific requirements between the rail and waterborne modes. However, the MNL model cannot cater for such.

The method of estimation is that of maximum likelihood, in which the log likelihood function conditional upon β takes the form of (rf. to Train (2009) for mathematical proof):

$$LL(\beta) = \sum_{n=1}^{N} \sum_{i} \sum_{t} y_{n,i,t} \, lnP_{n,i,t} \quad (5)$$

With N the number of decision makers
$y_{n,i,t} = 1$ if decision maker n choses alternative i in choice task t, $y_{n,i,i} = 0$ otherwise
β = model parameters

In which the model parameters β are estimated for which the LL reaches its maximum:

$$\text{First order condition: } dLL(\beta)/d\beta = 0$$

As discussed in the survey chapter, the total number of decision makers N in this study is 20. The logistical managers were asked to make repeated choices for his or her company, either in a within-mode or between-mode choice setting. The MNL models estimated upon these observed freight transport choices are specified by the following utility functions, for which the utility of a given alternative (i) faced by a respondent (n) and per choice task (t) is described according to the between-mode or within-mode setting:

$$U_{between,i,n,t} = ASC_{i,n,t} + \beta_{TT} . TT_{i,n,t} + \beta_{TC} . \ln(TC_{i,n,t}) + \beta_{LD} . LD_{i,n,t} + \beta_{REL} . REL_{i,n,t} + \beta_{ENV} . \left(\frac{1}{1000000} ENV_{i,n,t}\right) . DT_n . TN_n + \varepsilon_{i,n,t} \quad (6)$$

$$U_{within,i,n,t} = ASC_{i,n,t} + \beta_{TT} . TT_{i,n,t} + \beta_{TC} . \ln(TC_{i,n,t}) + \beta_{ENV} . (\frac{1}{1000000} ENV_{i,n,t}) . DT_n . TN_n + \varepsilon_{i,n,t} \quad (7)$$

With:

$i \in \{1,2,3\}$ for the between-mode specified utility functions

$i \in \{road, rail, iww, sss\}$ for the within-mode specified utility functions

ASC: indicating the alternative specific constants with $ASC_{3,n,t} = 0$ and $ASC_{SSS,n,t} = 0$

TT, TC, LD, REL, ENV: the attributes transport time, transport cost, loss and damage and the environmental attribute with their respective coefficients β_{TT} β_{TC} β_{LD} β_{REL} β_{ENV}

DT and TN: distance and tonnage of the typical shipment

$\varepsilon_{i,n,t}$ ~ iid extreme value (≈ Gumbel distributed)

The between-mode specified utility functions are characterised by five attributes: transport time (TT), transport cost (TC), an environmental attribute (ENV), loss and damage (LD) and reliability (REL). The utility functions specified for the within-mode only include the first three listed attributes. The main motivation in doing so, was for reasons of comparability with existing studies on the value of time measure and value of environment. This will be discussed in the results chapters (chapter 5, section 5.2.5.2.).

A nonlinear specification for the cost attribute was used. A logarithmic specification is argued for as it is often used in the literature if the spread of a variable is wide, which is the case for the reference value for the transport cost attribute. However, the use of a logarithmic specification also implies that a given change in costs has a smaller effect at higher cost levels. Relating to the freight choice modelling literature, it has been advocated to let go of the linear-in-attributes assumption (Rotaris et al., 2012; Danielis and Marcucci, 2007). In addition, a logarithmic specification of the cost attribute was found to perform best compared to a linear specification during the estimation (based upon the LL and AIC/BIC criteria). This was also tested for the time attribute but did not result in better model results. The environmental attribute was interacted with the distance (DT) and tonnage (TN) as well as divided by a million to gain a readily usable coefficient value (β_{ENV}) for reasons of interpretation and willingness to pay measures as the attribute was expressed in CO_2 g/tonnes-km in the stated preferences choice tasks.

The ASCs indicate the alternative specific constants, which *"capture the average effect on utility of all factors that are not included in the model"* (Train, 2009, pp. 20). The ASCs for transport 3 (within-mode utility functions) and short sea shipping (between-mode utility functions) were set to zero to normalise the absolute levels of the constants. The use for ASCs in the unlabelled choice tasks is motivated to control for a left-to-right bias.

In terms of estimation and in line with the work of Morikawa (1989) and Bradley and Daly (1994), two scale parameters were introduced. This was done to account for the merging of the within-mode and between-mode choice data as well as the difference in attribute phrasing between the pilot and final survey (referral to chapter 4 on the survey). The between-mode choice data was scaled to the within-mode choice data, and the pilot choice data was scaled to the choice data of the final survey.

The MNL is an elegant model, yet due to its restrictive nature it is not a solution to all and has its limitations. It is limited in the sense that it enforces proportional substitution between the alternatives, but it does not allow more flexible substitution patterns. In addition, it allows for systematic taste variation, but not for random taste variation. And lastly, the error terms are uncorrelated over time. These limitations have been translated into different model developments which relax these restrictions to include more flexible substitution patterns (e.g. nested logit), allow for random taste heterogeneity (e.g. latent class, mixed logit) or correlation of the error terms over time and correlation between the error terms of alternatives (mixed logit error components) (Train, 2009).

The next model discussed and applied in this study is the increasingly popular mixed logit model, which allows for random taste variation.

3.3.2. Mixed multinomial logit model with random taste variation (MMNL)

The mixed logit model with random taste variation relaxes one of the restrictions of the previous MNL model (fixed taste parameters (β)), by allowing the taste parameters (β) to be randomly distributed. In other words, allowing for random taste heterogeneity across decision-makers. The utility function is then specified by:

$$U_{n,i,t} = V_{n,i,t} + \varepsilon_{n,i,t} \qquad (8)$$

With n = respondent
i = alternative
t = choice task
$\varepsilon_{i,n,t}$ ~ iid extreme value

$$V_{nit} = f(\beta, x_{n,i,t}, s_n) \qquad (9)$$

$$\beta \sim f(\beta|\theta) \qquad (10)$$

With the taste parameters vector β following a chosen distribution with parameters θ. It is important to state that the type of distribution is set by the researcher, estimating the corresponding parameters θ. The distributions tested will be listed below. Due to the randomness of the taste parameters, the choice probabilities become (rf. see Train (2009), chapter 6):

$$P_{nit} = \int L_{nit}(\beta)\ f(\beta|\theta)\ d\beta \qquad (11)$$

With: $f((\beta|\theta))$ density function

$$L_{nit}(\beta) = e^{V_{nit}(\beta)} \Big/ \sum_{j=1}^{J} \sum_t e^{V_{njt}(\beta)} \qquad (12)$$

The mixed logit notation used here is thus one of random taste coefficients. However, a different notation which takes the error components as focus can be viewed in chapter 6 of Train (2009).

Whereas the MNL was elegant in terms of estimation, resulting in a closed form log likelihood function, the MMNL requires simulation techniques for estimation. The simulated choice probabilities are derived by calculating the conditional probability (12) for a given draw r taken from the distribution specified for β and repeating this process for an amount of R draws to then calculate the average. The simulated choice probabilities (13) and simulated log

likelihood function which is maximised (14) are given as follows (see Train (2009) for mathematical derivation):

$$\widetilde{P_{nit}} = \frac{1}{R}\sum_{r=1}^{R} L_{nit}(\beta^r) \quad (13)$$

$$SLL = \sum_{n=1}^{N}\sum_{j=1}^{J}\sum_{t} d_{njt}\ \ln(\widetilde{P_{njt}}) \quad (14)$$

With: dnj =1 if respondent n choses alternative j and dnj =0 otherwise

Allowing for random taste variation in the coefficients of all the five attributes (cost, time, environment, loss & damage and reliability) considered in this study was tested. However, the model allowing for taste variation with regards to the cost, time and environmental attribute was found statistically to perform best based on the log likelihood, AIC and BIC criteria. This will be discussed in result chapter one (section 5.1.2). In terms of type of draws used, both Halton draws (conventional) as well as MLHS draws were tested (following Hess et al. (2006)). The model utility functions used are specified as follows (using Normal distributions for the random parameters):

$$\begin{aligned} U_{between,i,n,t} = {} & ASC_{i,n,t} + \beta_{TT_n} . TT_{i,n,t} + \beta_{TC_n} . \ln\left(TC_{i,n,t}\right) \\ & + \beta_{LD} . LD_{i,n,t} + \beta_{REL} . REL_{i,n,t} \\ & + \beta_{ENV_n} . \left(\frac{1}{1000000} ENV_{i,n,t}\right) . DT . TN) + \varepsilon_{i,n,t} \end{aligned} \quad (15)$$

$$\begin{aligned} U_{within,i,n,t} = {} & ASC_{i,n,t} + \beta_{TT_n} . TT_{i,n,t} + \\ & \beta_{TC_n} . \ln\left(TC_{i,n,t}\right) + \beta_{ENV_n} . \left(\frac{1}{1000000} ENV_{i,n,t}\right) . DT_n . TN_n + \varepsilon_{i,n,t} \end{aligned} \quad (16)$$

In which:

$$\beta_{TT_n} = \mu_{TT} + \sigma_{TT}\, \varphi_{TT_n}$$

$$\beta_{TC_n} = \mu_{TC} + \sigma_{TC}\, \varphi_{TC_n}$$

$$\beta_{K_n} = \mu_{ENV} + \sigma_{ENV}\, \varphi_{ENV_n}$$

With:

$i \in \{1,2,3\}$ for the between-mode specified utility functions

$i \in \{road, rail, iww, sss\}$ for the within-mode specified utility functions

ASC: indicating the alternative specific constants

TT, TC, LD, REL, ENV: the attributes transport time, transport cost, loss and damage and the environmental attribute with their respective coefficients $\beta_{TT_n}\ \beta_{TC_n} \beta_{LD}\ \beta_{REL}\ \beta_{ENV_n}$

DT and TN: distance and tonnage of the typical shipment

$\varepsilon_{i,n,t}$ ~ iid extreme value (≈ Gumbel distributed)

β_{TTn} ~ Normal(μ_{TT},σ_{TT})

β_{TCn} ~ Normal(μ_{TC},σ_{TC})

β_{ENVn} ~ Normal(μ_{ENV},σ_{ENV})

φ_{TT_n}, φ_{TC_n}, φ_{ENV_n}: standard normal variates (notation following Bhat (2001))

In terms of distributions chosen for the random taste coefficients, both the conventionally used Normal (Gaussian) as well as (negative) Lognormal distributions were tested in the modelling stage. These distributions have been conventionally used in practice, however, an extensive argument to move away from these distributions is given in Axhausen et al. (2005). Nevertheless, for reasons of computational ease and considering the limited data sample size it is opted to remain with the usage of the Normal and negative Lognormal distributions and other distributions such as for example a uniform distribution or triangular distributions were not tested. The implications of using a normal distribution is that the researcher assumes that there are both positive and negative values of a given coefficient corresponding to an attribute (Train, 2009), therefore making an a priori assumption (Hess et al., 2005). Yet, from relevant freight mode choice literature we can assume a negative sign for the cost and time attribute for every decision-maker. The coefficient found in the study of Fries et al. (2010) also indicates a negative sign for the environmental attribute. Therefore, a Lognormal distribution was tested (argued in Axhausen et al., 2005), in which the negative is taken to acknowledge that the attributes are less desirable given a larger value. The utility functions then become:

$$U_{between,i,n,t} = ASC_{i,n,t} + TT_{i,n,t} \cdot (-\exp(\mu_{TT_n} + \sigma_{TT} \cdot \vartheta_{TT_n})) + \ln(TC_{i,n,t}) \cdot (-\exp(\mu_{TC} + \sigma_{TC}\, \vartheta_{TC_n})) + \beta_{LD} \cdot LD_{i,n,t} + \beta_{REL} \cdot REL_{i,n,t} + (-\exp(\mu_{ENV} + \sigma_{ENV}\, \vartheta_{ENV_n})) \cdot \left(\frac{1}{1000000}\ ENV_{i,n,t}\right) \cdot DT \cdot TN + \varepsilon_{i,n,t} \quad (17)$$

$$U_{within,i,n,t} = ASC_{i,n,t} + TT_{i,n,t} \cdot (-\exp(\mu_{TT_n} + \sigma_{TT} \cdot \vartheta_{TT_n})) + \ln(TC_{i,n,t}) \cdot (-\exp(\mu_{TC} + \sigma_{TC}\, \vartheta_{TC_n})) + (-\exp(\mu_{ENV} + \sigma_{ENV}\, \vartheta_{ENV_n})) \cdot (\tfrac{1}{1000000}\ ENV_{i,n,t}) \cdot DT \cdot TN + \varepsilon_{i,n,t} \quad (18)$$

With: ϑ_{TT_n}, ϑ_{TC_n}, ϑ_{ENV_n} random variates following (neg) lognormal distribution

The previously discussed models of the standard MNL and the ML were applied to address the research question (RQ1.A) directed at understanding logistic managers' preferences with regards to the impact of cost, time, loss and damage, reliability and CO_2 emissions on freight mode choice. Especially the MNL, but also increasingly MMNL, are found widespread in the freight mode choice literature to address such questions and can be regarded as conventional practise. To address the impact of environmental attitudes (RQ1.B and RQ1.C) on freight mode

choice, however, a hybrid choice model framework (specifically: ICLV) was applied. This will be discussed in the next section.

3.3.3 Integrated Choice and Latent Variable (ICLV) model

In recent years, hybrid choice models have become increasingly popular among choice modellers, especially in the transport passenger literature. Applications in the freight transport literature are scarce and those found were discussed in the literature chapter. Up to the author's knowledge, this research provides the first hybrid freight choice model that accounts for underlying environmental attitudes of freight shippers in their mode choices. Specifically, an integrated choice and latent variable model (ICLV) was used.

Put simply, a hybrid choice models boils down to a choice model which is expanded to include psychometric latent variables such as for example attitudes and perceptions. It has been repeated in the literature that not recognising the latent nature of psychometric constructs and directly incorporating the indicators of these into the utility functions (as done with for example socio-demographic variables) can lead to model measurement error and potential endogeneity bias as indicators are likely to be correlated (see Klojgaard and Hess (2014)). Therefore, it is advised to recognise the latent nature of such constructs and include these using a hybrid framework. The selected papers of Ben-Akiva et al. (2002), Bolduc et al. (2005), Bolduc and Daziano (2010), Daly et al. (2012), Daziano and Bolduc (2013) and Bahamonde-Birke and Ortuzar (2015) provide an overview of the theoretical advancements of hybrid choice models as well as practical examples.

Similar as in the MNL and MMNL models, the decision-maker's utility he or she obtains from a choice alternative is represented by utility functions, which are described for a given alternative (i), faced by respondent (n) and per choice task (t) as in equation (8). However, the deterministic part of utility as described in its functional form in equation (9) is now extended to include the latent variables (LV_I_n, LV_C_n) and the vectors of parameters (τ_I, τ_C) that measure the impact of the latent variables in the utility functions (a notation as in Kløjgaard and Hess (2014) is followed):

$$V_{nit} = f(\beta, x_{nit}, s_n, LV\_I_n, LV\_C_n, \tau\_I, \tau\_C) \quad (19)$$

As in the MNL and MMNL, the utility functions are specified per within-mode or between-mode context in which the different use of attributes is kept consistent. The environmental attribute is kept interacting with the distance and tonnages of the typical shipment to attain a result listed per gram CO_2 and the non-linear specification of the cost attribute is continued.

Differently from the MNL and ML models, two latent constructs (LV_I_n and LV_C_n) are introduced in the utility functions to account for environmental attitudes. One latent variable is specified on the individual level I and another is specified on the corporate level C. These interact directly with the alternatives or modes and the time, cost and environmental attributes. The utility functions are specified as followed:

$$\begin{aligned} U_{between,i,n,t} = {} & ASC_{i,n,t} + \tau\_I_i \,.\, LV\_I_n + \tau\_C_i \,.\, LV\_C_n \\ & + TT_{i,n,t} \,.\, (-\exp(\beta_{TT} + \tau\_I_{TTi} \,.\, LV\_I_n + \tau\_C_{TTi} \,.\, LV\_C_n)) \\ & + \ln(TC_{i,n,t}) \,.\, (-\exp(\beta_{TC} + \tau\_I_{TCi}\, LV\_I_n + \tau\_C_{TCi} \,.\, LV\_C_n))) \\ & + LD_{i,n,t} \,.\, \beta_{LD} \,.+ REL_{i,n,t} \,.\, \beta_{REL} \\ & + \left(\frac{1}{1000000} ENV_{i,n,t}\right) DT.TN \,.\, (-exp(\beta_{ENVi} + \tau\_I_{ENVi} \,.\, LV\_I_n \\ & + \tau\_C_{ENVi} \,.\, LV\_C_n)) + \varepsilon_{i,n,t} \end{aligned} \quad (20)$$

$$\begin{aligned} U_{within,i,n,t} = {} & ASC_{i,n,t} + TT_{i,n,t} \,.\, (-\exp(\beta_{TT} + \tau\_I_{TTi} \,.\, LV\_I_n + \tau\_C_{TTi} \,.\, LV\_C_n)) \\ & + \ln(TC_{i,n,t}) \,.\, (-\exp(\beta_{TC} + \tau\_I_{TCi}\, LV\_I_n + \tau\_C_{TCi} \,.\, LV\_C_n))) \\ & + \left(\frac{1}{1000000} ENV_{i,n,t}\right) DT.TN \,.\, (-exp(\beta_{ENVi} + \tau\_I_{ENVi} \,.\, LV\_I_n \\ & + \tau\_C_{ENVi} \,.\, LV\_C_n)) + \varepsilon_{i,n,t} \end{aligned} \quad (21)$$

With:

$i \in \{1,2,3\}$ for the between-mode specified utility functions

$i \in \{road, rail, iww, sss\}$ for the within-mode specified utility functions

ASC: indicating the alternative specific constants

LV_I_n: the environmental latent variable on the individual level with k indicators $\in \{1,2,3,4,5\}$

LV_C_n : the environmental latent variable on the corporate level with k indicators $\in \{6,7,8,9\}$

τ_I_i and τ_C_i: the interaction effects of the latent variables with the mode

$\tau\_I_{ATTRIBUTEi}$ and $\tau\_C_{ATTRIBUTEi}$: the interaction effects of the latent variables with the attributes

TT, TC, LD, REL, ENV: the attributes transport time, transport cost, loss and damage and the environmental attribute with their respective coefficients β_{TT} β_{TC} β_{LD} β_{REL} β_{ENV}

τ_I_{ENVi} and τ_C_{ENVi}: the interaction effect of the latent variables with the environmental attribute

DT and TN: distance and tonnage of the typical shipment

$\varepsilon_{i,n,t}$: random component ~ iid extreme value (≈ Gumbel distributed)

In addition to the utility functions, the two latent variables used in the model are described for each individual (n), consisting of a deterministic part (conventionally including socio-demographic variables) f(z_n , γ) and a random part (η). Only a linear specification of the deterministic part in these structural equations of the latent variables in the ICLV model was tested. Socio-demographic variables such as gender, education, income and age, but also company characteristics such as company size or years of service were tested to identify the model (Vij and Walker, 2016). However, issues in terms of model stability were encountered and will be discussed in the results chapter (section 5.1.3). Estimation resulted in the use of the socio-economic variable gender to specify $f(z_n , \gamma)$. The error terms (η) are set to follow a Normal distribution with mean zero and a covariance matrix Ω_η in which it is assumed that the off-diagonal in the matrix are zero, following the work of Kløjgaard and Hess (2014). In doing so, it is assumes that $LV_{I,n}$ and $LV_{C,n}$ are not correlated. This assumption can be relaxed by introducing a Choleski factor between the two error terms (Train, 2009). However, testing such did not result in stable model estimates and therefore the structural equations of the latent variables below will not include a Choleski factor:

$$LV\_I_n = f(z_n , \gamma_I) + \eta_{LVI,n} \qquad (22)$$
$$LV\_C_n = f(z_n , \gamma_C) + \eta_{LVC,n} \qquad (23)$$

With: $\eta_{LVI,n}$ and $\eta_{LVC,n}$ ~ Normal with mean zero and covariance matrix Ω_η

With: $f(z_n , \gamma_I) = \gamma_{I,n} . z_{GENDER,n}$
$f(z_n , \gamma_C) = \gamma_{C,n} . z_{GENDER,n}$

In terms of accounting for the scale of the latent variables, both the “Ben-Akiva type” (Ben-Akiva et al., 1999) and “Bolduc-type” (Bolduc et al., 2005) of normalisation techniques were tested. However, based on model results it was decided to use follow the “Bolduc-type” normalisation.

The third and last part of a hybrid choice model are the indicator functions, also known as the measurement model component of the ICLV model. The latent constructs capturing environmental attitudes on the individual and corporate specified levels in the model are used to explain (the choices observed in the choice tasks and) the indicators of such attitudes. As discussed in the survey chapter (Chapter 4), different statements or attitudinal questions were formulated on the individual and corporate level using a six-point Likert Scale. From these,

four indicators were specified for the individual level ($I_{I,k}$) and five indicators were specified for the corporate level ($I_{C,k}$). The selection of these will be discussed in the results chapter (section 5.1.3.), as conventional Factor Analysis was not found statistically robust at first. Because of the limited sample size, it was decided to treat the indicators as continuous and subtracting their mean to be in the line with the work of Klojgaard and Hess (2014) (i.e. centring the indicators on zero). The distribution used for the random components (ν) is then a normal distribution with mean zero. However, it should be noted that it would be more rigorous and correct to recognise the ordered nature of the indicator statements following the work of Daly et al. (2012). The indicator functions are described as follows, in which it was opted to assume a linear specification with regards to the sensitivities of the indicators to the latent variables:

$$I_{I,k} = \rho_{I_{k,I}} + \zeta_{I_{I,k}} . LV\_I_n + \nu_{k,I} \quad (24)$$

$$I_{C,k} = \rho_{I_{k,C}} + \zeta_{I_{C,k}} . LV\_C_n + \nu_{k,C} \quad (25)$$

With:
$\zeta_{I_{I,k}}$ and $\zeta_{I_{C,k}}$ being the sensitivities of the indicators to the latent variables
$\nu_{k,I}$ and $\nu_{k,C}$ random disturbances
$\rho_{I_k,I,C}$ vectors of constants (made redundant by centering indicators to zero, see Klojgaard and Hess (2014))

Considering the continuous treatment of the indicators and the chosen normal distribution with mean zero for the random components, following Klojgaard and Hess (2014), the probabilities (relating to the indicators specified on the individual and corporate level) for indicator $I_{I,C,k}$ and the probabilities of K indicators for respondent n are described by:

$$P_{I_{I,C,k}} = \frac{1}{\sigma_{I,C,k}\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{I_{I,C,k} - \zeta_{I_{I,C,k}} LV_{I I,C,k}}{\sigma_{I,C,k}}\right)^2} \quad (26)$$

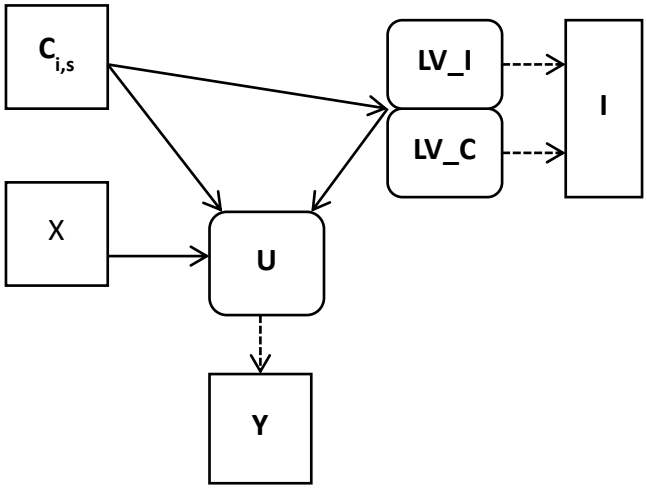
$$P_{I_{I,C,n}|LV_{I,C,n}\zeta_{I,C},\Omega_{I_{I,C}}} = \prod_{k=1}^{K} P_{I_{I,C,n,k}} \quad (27)$$

With: $\zeta_{I,C}$ vector of sensitivities of the indicators to the latent variables
$\Omega_{I_{I,C}}$ parameters specifying measurement model

Graphically, the model is represented in Figure 7 below. It needs to be noted that this representation is based upon the graphical display in Ben-Akiva et al. (2002). A squared box indicates that the variable is observed, a rounded box indicates that the variable is unobserved (or latent). Y indicates the choices gained from the stated preferences choice tasks, whereas

U represents the utilities. X are the attributes of the choice alternatives and $C_{i,s}$ the characteristics of the company (i) or typical shipment (s). I groups the indicator statements, and LV_I and LV_C are the latent variables respectively on the individual or corporate level.

Figure 7: Hybrid model structure



In terms of estimation of the hybrid choice model, two main techniques can be found in the DCM literature: either taking a sequential or simultaneous estimation approach. The simultaneous approach (ICLV), following Ben-Akiva et al. (2002b) and Bolduc et al. (2005), was followed to increase efficiency and consistency of the estimation properties (Daziano and Bolduc, 2013). Both Halton and established Modified Latin Hypercube Sampling (MLHS) random draws were tested (see Hess et al. (2006) for the use of MLHS). Parameter stability was controlled for by stepwise increasing the number of draws. The repeated choice nature of the data was acknowledged by carrying out all integration at the level of the individual respondent.

As described it is opted to estimate the different components of the model simultaneously, these include the vector of taste parameters relating to the choice mode (β), the vector of sensitivity parameters of the socio-demographic gender variable on the latent variables ($\gamma_{I,C}$), vector of sensitivity parameters of the latent variables in the utility functions ($\tau_{I,C}$), the vector of sensitivities of the indicators to the latent variables ($\zeta_{I,C}$) ,the measurement specification model parameter ($\Omega_{I,C}$) and the covariance matrix relating to the random disturbances in the

structural equations of the latent variables ($\Omega_{\eta_{I,C}}$). The loglikelihood function is specified as follows:

$$LL\left(\beta, \gamma_{I,C}, \tau_{I,C}, \zeta_{I,C}, \Omega_{I_{I,C}}\right) = \sum_{n=1}^{N} ln \int_{\beta} \int_{LV_{I,C}} P_{y_n} P_{I_{I,C,n}} \phi(\eta)\, m(\beta) d\beta\, dLV_{I,C} \quad (28)$$

With:
m(β) a function of the estimated vector of taste parameters β
η normalised with mean 0 and variances set to one ("Bolduc"-type normalisation)
$P_{y_n} = \sum_t \frac{e^{V_{i,n,t}}}{\sum_{j=1}^{J} e^{V_{n,j,t}}}$ choice likelihood (see Kløjgaard and Hess (2014))

The main motivation to apply the ICLV framework as argued in the introduction is twofold, namely the research interest on the role of environmental attitudes and potential efficiency gains in light of a limited sample size. However, a critical reflection on applying the model and the interpretation of its results is advised for the following reasons.

Firstly, important issues in terms of forecasting have been raised by Chorus and Kroesen (2014). However, the aim of this research is not to produce forecasts. In addition, these authors further criticise the assumed causality of the attitudes on behaviour in the models (Kroesen et al., 2017; Kroesen and Chorus, 2018). Interestingly, they find a large effect of the direction from behaviour onto attitudes (Kroesen et al., 2017) and recently go further in challenging the assumed causal direction from attitudes on behaviour (Kroesen and Chorus, 2018). This critique is important with regards to the interpretation of the results coming out of the ICLV, especially when making policy recommendations. Thirdly, while the paper of Vij and Walker (2016) is cited to justify the use of the ICLV model in this research application (potential efficiency gains in the presence of very sparse data), it also warns of the pitfalls that many applied studies overlook in terms of justifying the use of a hybrid choice framework. Lastly, the work of Bahamonde-Birke et al. (2017) stresses the need for careful analysis to the manner in which attitudes (and perceptions) are included. The theoretical debate on such models as well as the implementation and interpretation of applications is still ongoing. Therefore, the results reported from the ICLV model needs to be cautiously approached with these studies in mind.

The main quantitative technique of choice modelling and the applied models have each been discussed. Following this, the main qualitative technique will now be discussed.

3.4. QL: thematic analysis

The qualitative component in the mixed method research design is added to gain an in-depth understanding of the company contextual setting with regards to mode choice (RQ1.E and RQ1.D) and a freight modal shift (RQ3.1 and RQ3.2) from the point of view or perception of the interviewee. In addition, it explores the experiences during the stated preferences survey of the interviewee with the aim of deriving useful practical insights with regards to using SP in the freight mode choice context (RQ2.1 and RQ2.2).

The qualitative methodology makes use of face-to-face semi-structured interviews, using an interview protocol (also called interview guide or "script") containing semi-structured open-ended questions. For example, the first question of the interview was: "Could you describe the situation for incoming and outgoing typical transport flows to and from your company?". This example is given as it shows good practise in interviewing to make the respondent at ease by asking a first question to which he or she knows the answer (Berg, 2007). In addition, probe questions were used to gain more detail or clarify given answers. The semi-structured nature allows the interviewer to ask additional questions which are formed based on the answers given by the interviewee (Bryman, 2001). In other words, it permits a certain degree of flexibility, while the interview protocol ensures that all questions are covered.

Both interviews as well as focus groups are popular and widely used tools of qualitative research (Bryman, 2001). However, the choice was made to conduct interviews and not focus groups for three main reasons. Firstly, the stated preference survey which forms the main quantitative component of the data collection was performed following the CAPI (Computer Aided Personal Interview, rf. chapter four) approach. Considering the presence of a personal interviewer, qualitative interviews were therefore easy to match and combine with the CAPI approach for the SP. Secondly, while focus groups derive interesting insights based on group interaction and collective knowledge, they require a high degree of commitment and active engagement of all the participants. In addition, focus groups require the presence of a group of participants at one moment in time. This was assumed too burdensome to achieve in the context of this research as the interviewees consist of corporate managers with strict agenda and time restrictions. The third motivation is linked to the potential limitations inherent to the

organisation of focus groups. These are the potential loss of control of the conversation as specific and advanced moderator skills are needed to manage a group, difficult transcripts due to multiple (sometimes even simultaneous) voices, inaudible effects which are reflected in group behaviour and other group effects (for example overprominent participants supressing others) (Bryan, 2001).

Four main topics were identified to form the four main blocks of interview questions to address the research questions: RQ1.D, RQ1.E, RQ2.1, RQ2.2, RQ3.1 and RQ3.2. The first topic refers to the transport organisation of flows to and from the company (qualitative interview question one: QLi.Q1). The question was intentionally left very open as the interviewer did not want to push views nor result in a potential focus on a variable that was used in the choice survey. In addition, only probe questions to elaborate further on given answers by the interviewee or to state important differences between the types of transport flows were asked. Interestingly, many interviewees elaborated not only on the current way transport flows go to and leave the company but also on past experiences. The second and third qualitative interview questions related directly back to comments made during the choice survey and validation of the choice survey (QLi.Q2 and QLi.Q3). The fourth topic consisted of perceived possible triggers for a modal shift of freight transport towards more sustainable modes for the Port of Ghent area (qualitative interview question four: QLi.Q4). It needs to be stressed that any potential interference of the open-ended questions with the stated choice experiments was minimised by timing the interview questions into two parts with regards to the choice survey: QLi.Q1 was asked before and QLi.Q2 till QLi.Q4 was asked after completion of all the choice tasks. The four main interview questions can be consulted in the interview protocol added in Appendix (9.3).

The method of analysis upon the transcribed interviews is that of thematic analysis (TA), in particular inductive thematic analysis.

Thematic analysis is widely applied in qualitative research and can be identified as *"a method for identifying, analysing, and reporting patterns (themes) within data"* (pp. 6, Braun and Clarke, 2006). However, the discussion whether TA can be regarded as a method on itself or a tool to be applied across different methods is still ongoing in the literature (Boyatzis, 1998; Bryan, 2001; King, 2004; Braun and Clarke, 2006; Nowell et al., 2017). It can be noted that the

view of TA as a method on itself is followed here and the reader is referred to the work of Braun and Clarke (2006).

The main unit of thematic analysis are themes, these are said to *"capture something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set"* (pp. 11, Braun and Clarke, 2006). Inductive TA implies that the themes are data driven or put differently, emerge from the data (Elo and Kyngäs, 2008). It is characterised by its bottom-up approach (Bryman, 2001). In contrast, deductive TA uses theory as a coding lens. It is characterised by its top-down approach in which previous knowledge forms the category structure and it is mostly used in the context of theory testing.

It was decided to follow inductive TA as it is most appropriate to the research context. Other qualitative methods such as the widely used discourse analysis and conversation analysis, which both focus on which and how language is used, or narrative analysis, which emphasises upon stories, were not followed. Inductive TA is appropriate for the following reasons. Firstly, inductive TA lends itself easily to fit with the pragmatic paradigm followed by the mixed methods research design in the sense that it starts from the research questions and not a strong epistemological theoretical lens. Secondly, the choice was made to start coding themes from scratch and not to use existing thematic coding from previous studies for the simple reason that such coding structures are not available. Thirdly, thematic analysis lends itself to be flexible to the needs of a particular study (Braun and Clarke, 2006). In particular to this application, it fits the research needs to cover multiple research questions in which the answers are potentially interrelated. This is confirmed in the results chapters two and three.

The main tool used to conduct the TA is that of node coding, which in essence comes down to organising the data by *"categorizing segments of data with a short name that simultaneously summarizes and accounts for each piece of data"* (pp.43, Charmaz, 2006). In other words, it implies adding tags or naming specific sections in the transcribed interview-text. The software used to facilitate the node coding process was that of Nvivo (QSR International, 2015). Following the typology of Strauss and Corbin (1990), two types of coding practises were combined: open coding and axial coding. On the one hand, open coding served as an initial coding phase from which concepts were identified and grouped into categories. On the other

hand, axial coding examined the connections between the different codes (Strauss and Corbin, 1990). Three main phases are identified in the coding process used in this research. After first familiarising oneself with the data (following Braun and Clarke (2006)), the first phase consisted of initial node coding per interview. This is consistent with Charmaz (2006) which identifies initial coding as coding in which *"fragments of data – words, lines, segments, and incidents – closely to their analytic import"* are studied (pp. 42, Charmaz, 2006). In addition, reflections and research memo notes were made that included initial ideas of emerging themes, reflections on initial insights and reflections on the coding process itself. To ensure that the context of the tags (or codes) was not lost, larger segments or sections of texts were included into the tag (Bryan, 2001). Each interview was initially coded separately and on a one-by-one basis. For each interview an overview document of the main insights and interesting particularities was made. The second phase consisted of sorting and organising the codes. This led to the formation of themes, not only interview specific themes, but also overarching themes across the data-set. This phase also included re-coding of certain themes and looking at the relationship between different codes and themes which led to the formation of sub-themes. Practically, this was done manually by constructing thematic maps (rf. results chapter 5.2). This described second phase can be understood as Charmaz' typology of focused coding, in which *"the most significant and/or frequent earlier codes"* are used *"to shift through large amounts of data"* (pp. 58, Charmaz, 2006). In addition, it also coincides with the third step in the TA process described by Braun and Clarke (2006), which brings the focus from codes towards the emergence of themes. Additionally, the overview documents per interview generated in the first phase were updated to include the thematic structure and additional insights. The third phase consisted of reviewing the themes, in which they were refined and checked for overlap or not being coherent in terms of inputs (consistent with Braun and Clarke (2006)). In addition, clusters of themes and clusters of interviewees were made to assess potential relationships. Again, general insights across the different interviews were gathered in an overview document.

As can be derived from the three coding phases, coding is a time-consuming and iterative process in which the initial detailed code is re-assessed, patterns between codes and patterns between themes are examined and extensive review of the codes and themes is needed.

The next section will present the integrated model, which attempts to integrate the qualitative themes into a choice model framework to exploratively assess their potential quantitative impact on mode choice.

3.5. Integrated model: environmental attitudes, choices and themes

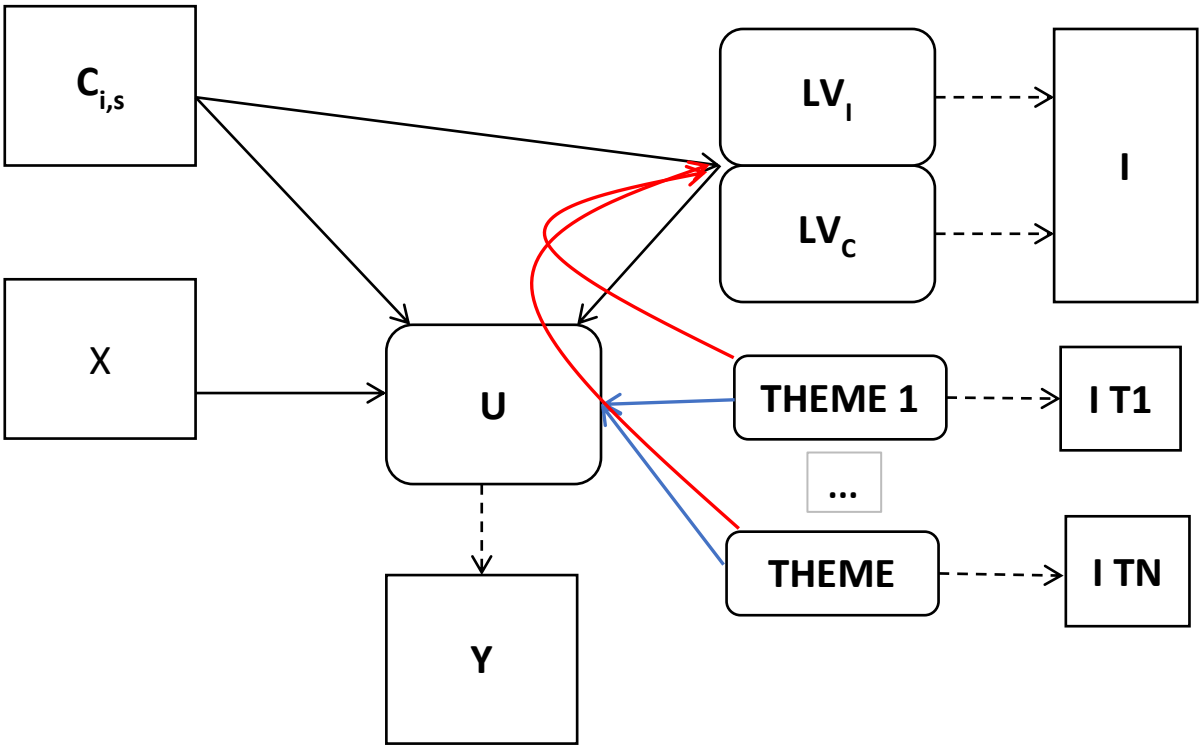
While choice models such as the MNL and MMNL are applied to assess freight mode choice and an ICLV was introduced to account for environmental attitudes, qualitative analysis resulted in the emergence of themes which relate to: the company contextual setting, SP experiences of the participants and the modal shift topic. While each technique can stand on its own, a model structure will be presented in this section to explore the potential relationship between the freight mode choices made, environmental attitudes and presence of themes. The main question underlying this is directed at assessing the potential impact of qualitative themes on mode choice. 'Presence of a theme' indicates that the interviewee discussed such theme during the interview. It needs to be noted that this is explorative of nature and only a basic inclusion of the qualitative themes into a model framework was tested.

A quantification of the qualitative themes was derived by creating binary dummy variables: zero when the theme was not elaborated upon by the participant and one if the theme was present for the participant.

The first round of modelling consisted of adding the dummy variables one-by-one to a basic MNL model in which they were treated as covariates interacting with the environmental attribute (CO_2 emissions). However, the same critique already mentioned in section 3.3.3. on recognising the latent nature and properly integrating these constructs using an ICLV framework to avoid model measurement error and endogeneity bias applies (rf. Klojgaard and Hess (2014)). The aim was to have a first model test round to see which themes interacted significantly and which ones didn't. This served as a model strategy to include them in the aspired ICLV framework.

Secondly, the themes were added on a one-by-one basis to a base hybrid in which they were treated as covariates to interact with a model including two LV's (personal and corporate environmental friendliness). It is recognised that this followed trial and error model approach is computational burdensome and time consuming (94 models were estimated). Unfortunately, it needs to be recognised that these trials were performed with an unidentified model structure and therefore are not useable. Three potential ICLV model structures were considered and tested with the former unidentified model structure, these are indicated by the different arrows in Figure 8 below. The red arrows indicate model structure one, the blue errors indicate model structure two and the combination of both red and blue arrows indicates model structure three. Many model issues in terms of computation time, stability of the models and significance of the estimation results were encountered due to sample size restrictions and mis-specification (un-identified) of the model.

Figure 8: ICLV integrated model structures



Based upon model estimation results of the identified model as described in section 3.3. above, the improved model trials for the integrated models were based upon the output model including one latent variable to account for underlying environmental attitudes. In doing so, the derived clusters from the qualitative analysis were used to form groups of themes which were separately incorporated into the ICLV structure. One thematic cluster was selected to work with for the model based on criteria of relevance with regards to freight mode choice and the particular application. This is addressed in section 5.2.5 in chapter five. For each theme part of the thematic cluster group, a latent variable was formed which fed into the corresponding binary theme which served as an indicator. Many elements can be taken over from section 3.3 on the ICLV-MNL framework used, which is expanded to include latent variables to account for the presence of themes.

The blue arrow model structure as shown in Figure 8 was used as the emphasis lies on assessing the impact of the latent themes on mode choice. For each theme, a latent construct was used (LV_T), which interacted with the transport time, transport cost (tariff) and environmental attribute, as well as with the modes, likewise to the latent variable (LV_G) to account for environmental attitudes.

The ICLV model equations are given as follows:

Utility functions:

$$\begin{aligned} U_{between,i,n,t} = {} & ASC_{i,n,t} + \tau\_G_i \,.\, LV\_G_n + \tau\_T_i \,.\, LV\_T_n \\ & + TT_{i,n,t} \,.\, \left(-\exp\left(\beta_{TT} + \tau\_G_{TT_i} \,.\, LV\_G_n + \tau\_T_{TT_i} \,.\, LV\_T_n\right)\right) \\ & + \ln\left(TC_{i,n,t}\right) \,.\, \left(-\exp\left(\beta_{TC} + \tau\_G_{TC_i}\, LV\_G_n + \tau\_T_{TC_i} \,.\, LV\_T_n\right)\right) \\ & + \beta_{LD} \,.\, LD_{i,n,t} + \beta_{REL} \,.\, REL_{i,n,t} \\ & + \left(\frac{1}{1000000} ENV_{i,n,t}\right) DT.TN \,.\, \left(-exp\left(\beta_{ENV} + \tau\_G_{ENV_i} \,.\, LV\_G_n \right.\right. \\ & \left.\left. + \tau\_T_{ENV_i} \,.\, LV\_T_n\right)\right) + \varepsilon_{i,n,t} \end{aligned} \tag{29}$$

$$\begin{aligned} U_{within,i,n,t} = {} & ASC_{i,n,t} + TT_{i,n,t} \,.\, \left(-\exp\left(\beta_{TT} + \tau\_G_{TT_i} \,.\, LV\_G_n + \tau\_T_{TT_i} \,.\, LV\_T_n\right)\right) \\ & + \ln\left(TC_{i,n,t}\right) \,.\, \left(-\exp\left(\beta_{TC} + \tau\_G_{TC_i}\, LV\_G_n + \tau\_T_{TC_i} \,.\, LV\_T_n\right)\right) \\ & + \left(\frac{1}{1000000} ENV_{i,n,t}\right) DT.TN \,.\, \left(-exp\left(\beta_{ENV} + \tau\_G_{ENV_i} \,.\, LV\_G_n \right.\right. \\ & \left.\left. + \tau\_T_{ENV_i} \,.\, LV\_T_n\right)\right) + \varepsilon_{i,n,t} \end{aligned} \tag{30}$$

With:

$i \in \{1,2,3\}$ for the between-mode specified utility functions

$i \in \{road, rail, iww, sss\}$ for the within-mode specified utility functions

ASC: indicating the alternative specific constants

LV_G : the environmental latent variable on the individual level with k indicators $\in \{1,2,3,4,\}$

LV_T: the thematic latent variable with corresponding dummy theme as indicator

$\tau\_G_{i,}$: the interaction effects of the environmental latent variable with the mode

$\tau\_T_{i,}$: the interaction effects of the theme latent variable with the mode

TT, TC, LD, REL, ENV: the attributes transport time, transport cost, loss and damage and the environmental attribute with their respective coefficients β_{TT} β_{TC} β_{LD} β_{REL} β_{ENV}

τ_G_{TTi} and τ_T_{TTi}: the interaction effect of the latent variables with the transport time attribute

τ_G_{TCi} and τ_T_{TCi}: the interaction effect of the latent variables with the transport cost attribute

τ_G_{ENVi} and τ_T_{ENVi}: : the interaction effect of the latent variables with the environmental attribute

DT and TN: distance and tonnage of the typical shipment

$\varepsilon_{i,n,t}$: random component iid extreme value (≈ Gumbel distributed)

Structural equations latent variables:

$$LV\_G_n = f(z_n, \gamma_G) + \eta_{LV\_G,n} \qquad (31)$$
$$LV\_T_n = f(z_n, \gamma_T) + \eta_{LV\_T,n} \qquad (32)$$

With: $\eta_{LV\_G,n}$ and $\eta_{LV\_T,n}$ ~ Normal with mean zero and covariance matrix Ω_η (LV's uncorrelated)

And: $f(z_n, \gamma_G) = \gamma_{G,n} . z_{GENDER,n}$

$f(z_n, \gamma_T) = \gamma_{T,n} . z_{GENDER,n}$

Indicator functions:

$$I_{G,k} = \rho_{G_{I,k}} + \zeta_{I_{G,k}} . LV\_G_n + \nu_{k,G} \qquad (33)$$
$$I_{T,k} = \rho_{I_{T,k}} + \zeta_{I_{T,k}} . LV\_T_n + \nu_{k,T} \qquad (34)$$

With:

$\zeta_{I_{G,k}}$ and $\zeta_{I_{T,k}}$ being the sensitivities of the indicators to the latent variables

$\nu_{k,G}$ and $\nu_{k,T}$ random disturbances

$\rho_{I_k,G,T}$ vectors of constants (made redundant by centering indicators to zero, see Klojgaard and Hess (2014))

Loglikelihood functional form:

$$LL(\beta, \gamma_{G,T}, \tau_{G,T}, \zeta_{G,T}, \Omega_{I_{G,T}}) = \sum_{n=1}^{N} ln \int_\beta \int_{LV_{G,T}} P_{y_n} P_{I_{G,T,n}} \phi(\eta)\, m(\beta) d\beta\, dLV_{G,T} \qquad (35)$$

With: m(β) a function of the estimated vector of taste parameters β

η normalised with mean 0 and variances set to one ("Bolduc"-type normalisation)

Similar to section 3.3, "Bolduc-type" normalisation was applied to account for the scale of the latent variables and the indicators were centred to zero by subtracting their sample mean. Also, no correlation was assumed between the latent variables. However, potential

correlation was not tested by adding a Choleski factor due to the preliminary model testing phase. This could be explored in future modelling steps.

3.6. Reflection

By applying a mixed methods methodological framework, both quantitative as well as qualitative techniques were integrated and combined. Arguments were given as to why a mixed methods approach is found appropriate as well its advantages were highlighted. However, it needs to be stated that mixed methods is not a holy grail. Simply combining a qualitative technique with a quantitative technique does not necessarily result in the envisioned advantage of gaining both in-depth insights as well as generalisable results at the same time. A mixed methods design will inherently have a context or case-study specific setting. Considering the policy relevance to the case-study area of the Port of Ghent region, this is actively sought in this research application.

Choice modelling has a long-standing tradition in assessing mode choice and was therefore also applied in this research. However, it needs to be noted that other quantitative methods have been applied to assess decision-making with regards to freight transportation. For example, a game theoretic setting to assess decision-making between freight shippers and carriers has been applied in the literature. The study of Holguín-Veras et al. (2011) serves as an example of a game-theoretic application to assess freight mode choice and shipment size. However, considering the available resources for the project and the specific interest on shipper's mode choice, it was decided to remain within the well-established method of choice modelling.

Lastly, sailing the sea between a quantitative orientated view on the world (or better knowledge) and a qualitative orientated view of the world (or better knowledge) is not straightforward. However, by following the pragmatic framework of mixed methods key-author Cresswell, a potential window is given to find common ground.

The results will be highlighted in chapter five for each method separately and combined where integration of the two techniques took place.

4. Case Study and Integrated Survey

4.1. Introduction

The survey was developed to address both quantitative as well as qualitative data requirements. It follows out of the mixed methods convergent design as described in the methodology chapter. Qualitative data was gathered by in-depth semi-structured interviews, whereas quantitative choice data and attitudinal data were obtained by conducting a stated preferences survey and attitudinal questionnaire. The choice data collected by the stated preferences survey are freight choices using a typical transport setting and different key-identified attributes to characterise the alternatives. The stated preferences component was designed according to a d-efficient design following the work of Rose and Bliemer (2009). It is a pivoted design having both a within-mode and a between-mode component. The qualitative and quantitative components were brought together in an integrated survey design.

A pilot version ran in winter 2015. Initial MNL model results and insights derived on feedback given by the respondents were incorporated to derive the final survey. The final survey ran until the end of spring 2016, with additional data gathering attempts in 2017.

The logistics managers of freight shipper's companies located in the Port of Ghent region were targeted. All components of the integrated survey were conducted in a single meeting per respondent, which took between an hour to an hour and 40 minutes depending on the participant. Each meeting followed a strict structure. The first step consisted of a brief introduction by the interviewer to outline the course of the meeting. This included introducing the researcher, explaining the cooperation with the Port of Ghent Authority and informing the interviewee on the meeting agenda. Secondly, University research ethic guidelines and administration were signed. Thirdly, the different types of data were gathered (QL interview data, SP choice data and attitudinal data). Relating to the open-ended interview questions, a strict protocol was followed. This will be highlighted in section 4.4.1. The interviewer started by asking the first QL interview questions on the current organisation of transport flows to and away from the company. Following this, the SP survey was conducted by Computer-Assisted Personal Interviewing (CAPI). Upon completion of all the SP choice tasks, QL interview

questions were asked by the interviewer (here the researcher) with regards to the perceived *"realism"* of the SP and with regards to the topic of a modal shift. The attitudinal paper questionnaire was handed lastly to the respondent. The researcher remained present during the completion of the attitudinal questionnaire, while finishing the administrative work on the computer. In other words, the researcher remained present to answer potential questions, but not dominantly as if looking over the participant's shoulder when filling in the survey. At the end of every meeting, a short debriefing took place to address additional questions that participants would have relating to the collection process, use of data, remarks etc. It needs to be stressed that the interviewer (here the researcher) was present to answer potential questions of the respondents and conduct the qualitative interviewing as well as to collect the stated preference and attitudinal surveys. However, the researcher did not guide the respondents in their answers and a strict interview protocol was used.

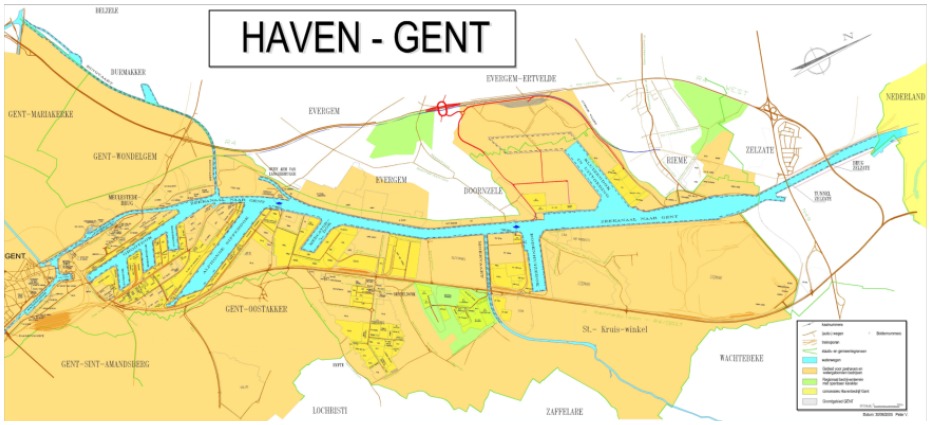
The overview of a data collection meeting with each respondent is summarised in the following list, in which the relevant sections of the survey chapter are indicated.

1. Introduction
2. University administration: consent form
3. Data collection
    a. QL interview Q1 (section 4.4.1)
    b. SP choice tasks (section 4.4.2)
    c. QL interview Q2-4 (section 4.4.1)
    d. Attitudinal paper questionnaire (section 4.4.3)
4. Debriefing

Each component of the integrated survey will be discussed. The chapter is structured as follows. Firstly, the Port of Ghent case study area is outlined in section 4.2. Secondly, the participants' profiles, targeting strategy and the composition of the sample is addressed in section 4.3. Thirdly, each component of the integrated survey design is discussed separately. Section 4.4.1. outlines the qualitative interview questions. Section 4.4.2 elaborates on the SP survey and respective statistical designs. The attitudinal questionnaire is addressed in section 4.4.3. Lastly, section 4.5 includes a reflection on the data collection process and describes the additional data collection effort that was undertaken.

4.2. Case study: Port of Ghent region

Figure 10: Port of Ghent map



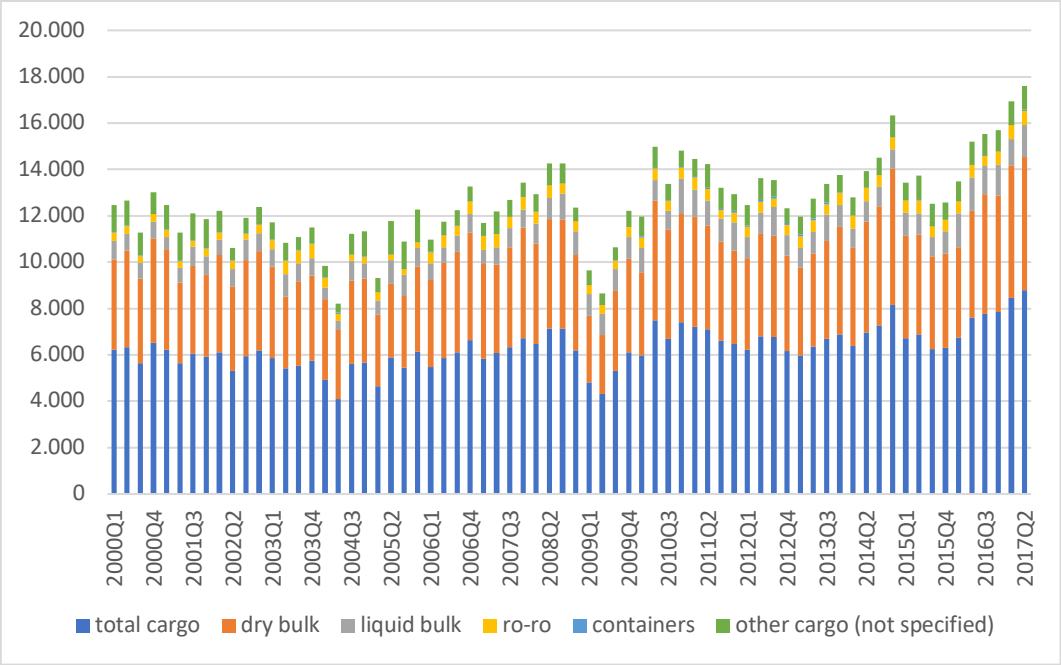
Source: Flemish Port Commission (2017)

The research focusses on the Port of Ghent region (Figure 10). The research fell together with an interesting time for the Port of Ghent Authority. In December 2017, the Port of Ghent Authority has officially merged with the authorities of the Ports of Vlissingen and Terneuzen (Zeeland Seaports). This led to the name of the North Sea Port. However, the application and derived findings will only refer to the Port of Ghent region. The Port of Ghent is an inland port in Belgium characterised by its connectivity by waterways towards France, the Netherlands and Germany. The port is connected to the North Sea by the Ghent-Terneuzen canal, with current locks allowing for vessels with a maximum draft of 12.5 meters. However, a new lock is under construction in Terneuzen. It is a collaboration between the Flemish and Dutch governments as well as the relevant Port authorities, now merged as the North Sea Port Authorities. The new lock, which is scheduled for completion in 2022, will provide increased connectivity for the port of Ghent in relation to the North Sea in terms of vessel size and entry capacity as larger ships will be able to enter. The lock will be 366 meters long, have a 49 meters width and 15 meters depth, which is comparable to the locks in Panama (Nieuwe Sluis Terneuzen, 2018).

The economic value of the Port of Ghent region for the East-Flemish province cannot be overlooked, as it generated 17.5% of the value added and covered up to 13% of the employment in the province in 2016 (Port of Ghent, 2017). The Port of Ghent dominantly handles bulk, with dry bulk taking the largest share in the range of goods handled. Figure 11

displays the gross weights by type of goods handled between the first quarter of 2000 and the second quarter of 2017. A slow but steady increase can be noted in the total cargo handled, with exception of the 2009 dip. It is important to highlight that the Port of Ghent is a 'value-added port' and not a container port as for example its neighbouring ports of Antwerp and Rotterdam, which process large volumes of containers. The label 'value-added port' implies that goods come into the port, are handled and mostly processed (value created). The majority of goods is then shipped out of the port again.

Figure 11: Gross weight of goods handled in the port of Ghent (in 1000tonnes)



Source: Eurostat database (2017)

The port of Ghent is a diversified port with catered storage and distribution facilities. In addition, it holds a broad company portfolio with sector presence ranging from automobile, petrochemical, wood, grain, building materials, food and others. It follows then that the goods handled in the port are heterogeneous and range from coal, cokes, iron ore, steel, anthracite, linseed, grain, wood (pellets), fruit juice, oil, scrap, fertilizers, chemicals etc. (Port of Ghent, 2016). However, no reference to the exact type of goods included in the sample will be made to safeguard the anonymity of the participating companies. It is acknowledged that each respondent will have taken the specific type of good as reference point when making choices based on their typical transport. In this line, a dominant dry bulk nature of the sample size is noted. The obtained sample will be highlighted in the next section.

4.3. The sample

One hundred freight shipper companies located in the port region were identified to be relevant for the study. It was opted to interview solely shippers for three main reasons. Firstly, the Port of Ghent is characterised in being a value-added port and shippers mostly reflect this nature as they create the added value through their production processes. Secondly, it needs to be noted that a rather low number of carriers is present in the port area as compared to shippers. A higher number of shippers compared to carriers can also be noted in large scale European freight surveys such as the Dutch and Norwegian value of time surveys (de Jong et al., 2014; Halse et al., 2010). Thirdly, Fries et al. (2010) argue that in the context of mode choice and environmental willingness to pay as is the case in this research, it is the preferences of the shippers that determine *"the potential demand for services with reduced environmental impact"* (Fries et al., 2010, pp33) as opposed to the providers of logistical services (carriers). However, the authors do make a side note that third or fourth-party logistics providers could also be used to assess environmental WTP in freight transports as they can influence transport demand when acting as replacements for shippers.

Multiple targeting efforts resulted in 20 shipper's companies that participated in the survey. This is a rather low participation rate (20%). Yet, a side note can be made that the overall population of 100 relevant companies is also compact as a total population number. However, it is difficult to achieve a high response rate with companies as the nature of the data is commercially sensitive. In addition, time restrictions of the targeted logistics managers are in place. This is not a challenge that relates only to this application but is found throughout freight shipper studies. For example, in the study of Swait et al. (1994) on combining SP and RP data on freight shipper choice targeted 1500 individuals across three different North American cities, which resulted in a 33% response rate. The largescale Norwegian freight Value of Time SP survey, which consists mostly of shippers but also combines with carriers, reports on a participation rate in the complete survey of 5.6% for shippers and 9.1% for carriers out of the total of 9626 firms targeted (Halse et al., 2010).

The logistical manager and CEOs of the companies were contacted by mail accompanied by a supporting information letter signed by the CEO of the Port of Ghent Authority and by the

(former) chairman of the employer's organisation: 'Flanders Chamber of Commerce and Industry - region East-Flanders' ("VOKA"). An additional target round consisted of sending the supporting information letter by post. The letters were sent out by the Port of Ghent Authority and aimed at important identified companies that did not reply in the first round. The companies additionally contacted by post mostly consisted of companies of significant economic importance in the Port of Ghent business portfolio.

The decision to target the logistical managers of shipper's companies to conduct a SP survey is in accordance to conventional freight mode choice literature (Tavasszy and de Jong, 2014). However, it assumes that decisions of the firm can be reduced to a single-unit decision maker. In other words, it results in a simplification of how choices in the firm are made and by whom. However, the role of the individual and the role of the firm in decision-making with regards to the transport mode will be addressed in the models by assessing the behavioural hypotheses that two distinct effects can be separated with regards to underlying environment attitudes (5.2.4). However, this is only a first step and additional research is advised.

Socio-economic information on the participants was collected, as well as company and typical shipment characteristics. A shipment indicates a typical transport carried out frequently by the company or for the company when outsourced. Data was collected both for an ingoing as well as an outgoing typical transport. The data on the participant, company and typical shipments was collected for modelling purposes, as for example potential interaction variables in the models.

The socio-economic variables include: gender, age, gross income and highest achieved level of education. In addition, the respondents' number of active years of service in the company was also asked. In the final sample, 75% were men, whereas 25% women. Table 3 gives an overview of the socio-economic variables with their corresponding key statistics in the sample.

Table 3: Overview sample socio-economic variables

	IDs	IDs missing	Mean	Std. Dev.	Min	Max
Age (years)	16	4	45,3	12,8	24	63
age male	11	4	47,8	13,2	24	63
age female	5	0	39,6	10,8	27	55
gross monthly income (EUR)	7	13	4686	3701,7	1900	12500
gross monthly income male (EUR)	4	11	5950	4683,7	1900	12500
gross annual income female (EUR)	3	2	3000,7	864,9	2002	3500
education score (1 to 4)	16	4	2,6	0,8	1	4
education score male	12	3	2,7	0,9	1	4
educations score female	4	1	2,5	0,6	2	3
1 = high school level. 2 = Bachelor 3 = MA/MSc 4 = MBA/PhD						
years of service	16	2	16,9	12,2	1	36
years of service male	11	2	18,6	11,7	1	36
years of service female	5	0	13	13,6	2	36

The company characteristics are the company size and the sector in which the company is active. The categories used for company size are defined using the European Commission's typology (EC, 2015). Medium-sized companies which are characterised (amongst other indicators) by less than 250 employees (headcounts) are the most represented in the sample (40%), followed by small companies who have less than 50 employees (30%) and large companies which have 250 plus employees (25%). Five percent did not report on the number of current employees. In terms of sector representation in the Port of Ghent region, nearly all relevant sectors are represented in the sample ranging from the petrochemical, wood, grain, steel and coal, food to automobile sectors.

The shipments characteristics were gathered both for a typical ingoing transport as well as for a typical outgoing transport, these include: product type, region of origin, region of destination, distance, frequency of the shipment, tariff cost, time (total, mode time, throughput and rest time), tonnages, main mode and all modes used for the typical transports. The 'total time' reflects the total time that a typical shipment takes from door-to-door in days, this includes shipping, handling, on and off-loading time. The 'mode time' indicates the days that the cargo spends on board of the vessel of the mode used (floating time, driving time or railing time), whereas the 'throughput time' -if any- indicates the period required for the cargo

to be transhipped. Rest time indicates the difference between the total time, the mode and throughput time as given by the respondent. If all the data on time was provided, this mostly indicated waiting time. It was observed that participants had easy access to the information on the total time of their typical transports. However, it was not straightforward to obtain specific data on mode or throughput time.

The dominant bulk-handling nature of the Port of Ghent region is mirrored in the sample, as 57.5% of the total product type share is bulk. However, an interesting difference can be noted between the typical ingoing and outgoing transports. Break bulk becomes the largest percentage share of the total of outgoing typical transports (see Table 4).

Table 4: %share of product type of typical transports per transport flow

Product Type	IN	OUT	ALL
Bulk	80%	35%	57.5%
Break Bulk	10%	45%	27.5%
General cargo	10%	10%	10%
Missing	0%	10%	5%

The Eastern European Region (EEU) and Western European Region (WEU) are strongly represented in the sample as destination region of the shipments (outgoing typical transports). The EEU and WEU region accounts for 90% of the sample, with the remaining 10% not being reported. Whereas the EEU and WEU region only account for 60% as origin regions of the shipments (ingoing typical transports), with the rest divided over South America (20%), Russia and Turkey (10%) and the Far East (5%).

The main modes used for the typical shipments differ across ingoing and outgoing flows to and from the shipper companies. In the sample, the focus for ingoing flows lies upon the “slow” modes, such as short sea (and sea) and inland shipping. In contrast, the focus lies on the “fast” mode (road) for outgoing typical transports (see Table 5).

Table 5: Main mode for typical transports per flow

Main Mode	IN	OUT
missing	0%	10%
road	20%	60%
rail	5%	5%
IWW	25%	15%
SSS(/sea)	50%	10%

Distance in km, frequency per week, total transport time in days and tonnage of the typical shipments are listed in Table 6. Information on tariff costs is not displayed for reasons of safeguarding sensitive business data. However, data on costs was acquired and used for the pivoted SP choice tasks.

Table 6: Shipment characteristics of typical transports

	shipments	missing shipments	Mean	Std. Dev.	Min	Max
distance (km)	38	2	2041,3	3163,0	48	12000
distance IN	20	0	3330,4	3948,0	60	12000
distance OUT	18	2	608,9	476,6	48	1500
Frequency (per week)	37	3	1876,8	10675,7	0,06	65000
frequency IN	20	0	27,9	81,5	0,06	365
frequency OUT	17	3	4051,8	15720,2	0,75	65000
total time shipment (days)	38	2	7,4	11,9	0,06	60
total time shipment IN	20	0	12,6	14,7	0,16	60
total time shipment OUT	18	2	1,6	0,1	0,06	3
tonnages shipment (tons)	38	2	6068,7	13573,9	3	70000
tonnages shipment IN	20	0	10896,3	17479,9	20	70000
tonnages shipment OUT	18	2	704,8	1279,8	3	3800
tariff cost shipment (€)	used in pivot design, not listed due to sensitive business nature					

The next sections will highlight the specific designs relating to each component of the integrated survey design.

4.4. Survey Design

A mixed methods approach is characterised by integrating both qualitative and quantitative techniques, with each technique relying on very different sources of data as input. Following this, the survey was designed to compose of three major components and integrate these. A qualitative interview component (QL), a stated preferences component (QN) and an attitudinal component (QN). Each will be described according to the nature of the type of data: qualitative or quantitative. Table 7 gives an overview of the different types of data collected with their corresponding analysis technique and software used.

Table 7: Data overview

	Data collection	**Analysis Tool**	**Software**
QL	Open-ended interview	Thematic Analysis	Nvivo
QN	Stated preferences choice experiment	Discrete Choice Modelling	Ngene (design), Rstudio (modelling)
	Attitudinal paper questionnaire	Factor Analysis and Integrated Choice and Latent Variable Model	Stata (factor analysis), Rstudio (modelling)

Firstly, the qualitative component of the survey will be highlighted in section 4.4.1. Secondly, the quantitative component including both the SP choice tasks as well as attitudinal questionnaires will be discussed in section 4.4.2.

4.4.1. The QL component of the survey

Qualitative data was collected by conducting face-to-face semi-structured open-ended interviews. An interview protocol (also called "script") was developed as a tool to guide the interview process in order to safeguard consistency across the participants as well as minimise response bias. Four main topics were identified on which the four main interview questions were formulated. In addition, probe questions were added in the protocol and used to gain more detail or clarify given answers (Berg, 2007).

Firstly, the respondent was asked to describe and discuss the current organisation of both the ingoing and outgoing flows to and originating from the company (Q1). The question was

intentionally left very open as the interviewer did not want to push views or put the focus on particular variables such as for example reliability and others that could influence the participant in his or her SP choice tasks. In addition, only probe questions to elaborate further on given answers by the interviewee or to ask on differences between the types of transport flows were asked. Interestingly, many interviewees were observed to not only elaborate on the current decision-making relating to mode choices in practice, but also on past experiences. It is argued good practice in interviewing to ask a first question to which the interviewee knows an answer (Berg, 2007). This was applied with Q1 in this interview.

The second and third interview questions were asked after completion of all the SP choice tasks and relate directly back to comments made during the SP survey and validation of the SP survey in terms of perceived *"realism"* to their decision-making upon mode choice in practice. As the SP survey consisted of both unlabelled and labelled choice tasks, the respondent was asked to reflect on any perceived differences in difficulty between the two (Q2), which was followed-up by asking directly about the perceived rationale behind the respondent's choice-making when completing the choice tasks as well as by asking to clarify given comments during the choice tasks (Q3). For example: if they had any doubts in particular choices, why some choices were more difficult than others to make, any remarks or shortcomings while choosing, given comments, etc.

The last interview question referred to possible perceived triggers of a modal shift of freight transport away from the road mode towards more sustainable modes for the Port of Ghent region (Q4). Again, probe questions were used to examine the respondents' beliefs towards certain policy incentives as well as market conditions that might trigger a modal shift toward sustainable modes.

In summary, Q1 explored on the specific company contextual setting on how the transport is organised while trying to initially examine which key-factors are stressed by the respondent, Q2 and Q3 are feedback and validation questions linking to the stated preferences choice tasks and Q4 shifts the focus to the topic of a potential modal shift towards more sustainable modes specific to the Port of Ghent region.

It needs to be stressed that any potential interference of answers given to the open-ended interview questions with the stated preferences survey was minimised. This was attained by splitting the open-ended interview questions into two parts: Q1 was asked before the SP choice tasks and Q2, Q3 and Q4 were asked after completion of all the choice tasks.

Audio recordings were made throughout the entire integrated survey and transcribed and analysed using Nvivo software (QSR International, 2015). The node coding structure in Nvivo is based upon categories using the qualitative method of thematic analysis as addressed in the methodology chapter.

The next sections will highlight the freight stated preferences survey and its statistical design.

4.4.2. The QN components of the survey: SP

4.4.2.1. Freight choice data

On the one hand, the quantitative data collected consists of choice observations obtained from a stated preferences survey using CAPI (Computer Aided Personal Interviewing). On the other hand, quantitative data on environmental attitudes was collected by paper survey. It was opted to have the attitudinal survey on paper and not part of the SP survey conducted on computer. This was done to safeguard the meeting flow by balancing the "computer time" and "off-screen time" and purposively defining the SP choice tasks to the respondents as the only component using a computer. Upon completion of the SP choice tasks, qualitative questions were posed as follow-up to the SP and on the topic of modal shift. This was described in the previous section. The attitudinal paper survey followed lastly. While the participant filled out the attitudinal paper survey, the researcher saved the work on the computer and cleared out the material. In doing so, the participant did not have direct supervision while answering to the environmental statements formulated on the personal and corporate levels. This was done to not guide the participants into his or her answers on the attitudinal questionnaires as well as respecting the participants space as the attitudinal survey specified on the level of the individual might have been perceived as politically sensitive.

Firstly, freight mode choice data was collected using a pivoted stated preferences survey. The main reason to collect stated preferences (SP) data was that there is no revealed preferences (RP) data available for the particular region and collecting such data with companies is very costly and very difficult to obtain due to the sensitive nature of the business activity. It is acknowledged that SP data has its limitations. The main limitation being the hypothetical nature of the choice data that does not necessarily translate into actual choices being made in practice (Train, 2009). In addition, it is not good practice to forecast based upon SP data alone. This follows out of the work on combining RP and SP data of Ben-Akiva and Morikawa (1990), Hensher and Bradley (1993) and Bradley and Daly (1993). In this research, however, SP is appropriate as multiple choice observations can easily be collected from a single decision maker. This is beneficial when facing a context in which the sample of real decision makers is small, as is the case in this freight application. In addition, forecasting is not a key objective. The research interest lies on understanding mode choice and deriving sensitivities upon model results such as the value of time, value of reliability, willingness to pay for a greener transport service or less loss and damage. SP has a long tradition in the literature of being an appropriate (yet not perfect) collection method for deriving such measures upon model results.

A choice observation is obtained by confronting a respondent with a choice task (CT). The respondent could choose from one of the alternatives specified in the choice task. The survey amounts to a total of 32 choice tasks per respondent. It is acknowledged that this is a higher number of CTs than commonly used in freight SP studies. However, it can be argued that the higher number of CTs can be justified due to the small sample of potential respondents. In addition, the SP survey did not only include a within-mode component, but also a between mode component, both for the incoming and the outgoing typical transport flows. This was done to optimize information given per respondent. The between-mode component was included for the mode choice research objectives as the choice tasks are labelled, whereas the within-mode component was included for computing VOT and VOR objectives as the choice tasks are non-labelled. However, an initial research objective was to compare WTP measures derived upon model results using the within-mode choice observations (as mostly applied in the literature) to those derived upon between-mode choice observations. Due to the low participation rate and resulting smaller choice sample size, the WTP measures were derived upon model results using all the choice observations.

Following this, each respondent was confronted with four different sets of eight CTs: within-mode (WM) ingoing typical transports (eight CTs), within-mode (WM) outgoing typical transports (eight CTs), between-mode (BM) ingoing typical transports (eight CTs) and between-mode (BM) outgoing typical transports (eight CTs). However, two respondents did not agree to give reference data with regards to their typical outgoing transports and therefore did not complete the CT sets for the outgoing typical transport flows.

A within-mode choice task is characterised by its alternatives being unlabelled. This implies that all alternatives refer to the same main mode. In this freight SP survey, the within-mode CTs are characterised by three unlabelled alternatives, each with three attributes: cost (tariff), transit time (door-to-door) and an environmental attribute (CO_2 emissions in g/tonne-km). The three unlabelled alternatives correspond with the main mode used for the typical transport, given by the respondent. The time attribute was expressed in days for a typical transport, whereas the cost attribute was expressed in tariff price (euros) of a typical transport (per transport, not per tonne). Both the time and cost attribute levels are pivoted upon reference data provided by the respondent. In doing so, it was aimed to make the stated preferences choice tasks more realistic or closer to the respondents' decision-making in practise. For the cost attribute, a symmetrical level range was applied. In contrast, an asymmetrical range in levels for the time attribute was used. The asymmetrical range in levels to the right (positive) meant that the transport time could increase disproportionately more than it could decrease. This was applied to trigger more sensitive transport time coefficient results. The environmental attribute is simplified into an attribute expressed in terms of varying levels of CO_2 gram per tonne-km. However, the pilot survey used GHG emissions as environmental attribute. This was done to be consistent with the previous work on freight shipper's environmental WTP measures reported in Fries et al. (2010). They expressed the environmental attribute in terms of absolute percentage-change in GHG emissions (-50%, status quo, +50%). Following Fries et al. (2010), the environmental attribute in the pilot SP survey was also expressed in absolute percentage-change of GHG emissions to the current. However, two additional levels were added. Multiple respondents who took part in the pilot survey expressed that they could not correctly interpret increases and decreases in this attribute due to unawareness of their current levels of GHG emissions per typical transport (i.e. lack of reference value) or even inability to fully grasp the meaning of percentage changes

in GHG emissions by transport mode. To address this stated issue, a simplified and heavily rounded European average of 40 g CO_2 per tonne-km was used as a calibration point for the respondent. In doing so, GHG emissions were narrowed down to CO_2 emissions. A graph (appendix: figure A) displaying average EU data on CO_2 emissions (g/tonne-km) between 1995 and 2011 across the road, rail, maritime and inland waterways mode (EEA, 2015) was shown prior to confronting the respondent with the choice tasks but after obtaining the reference data on time and cost. It is important to recognise the simplification of the environmental attribute to only CO_2 emissions. There is still much scope to explore on how to include and express an environmental attribute in freight SP surveys for future research. Inspiration could be found in the domains of environmental economics, ecological economics and the sustainability literature, in which different measures (but also philosophical views) on how to define and treat the environment circulate. A potential avenue to explore might involve looking into valuation mechanisms in the increasing popular concept of eco-system services in the ecological economics literature and its usage (for reference: Costanza et al. 1997 and de Groot et al. 2002). Or by understanding the alternative approach in the "Pachamama" (Mother Earth) philosophy, which has been made part of the law system in certain South-American countries such as Ecuador (see Daly, 2012).

The between-mode CTs are labelled according to the main mode used for the typical transport: road, rail, inland waterways (IWW) and short sea shipping (SSS). The emphasis is on the main mode as the rail, IWW and SSS modes are conventionally multimodal transports demanding an access and egress transport. Different to the within-mode CTs is the selection of attributes. Two more attributes (reliability, loss and damage) were added to the previous three (cost, time and CO_2 emissions). The difference in the number of attributes is argued as follows. The within-mode was originally solely designed to derive the WTP measures for time and the environment as expressed in CO_2 emissions. The between-mode is intended to gain more understanding and assessing the impact of key-identified attributes in the literature upon mode choice. In the pilot SP survey, the loss and damage attribute was expressed in percentage-change to the current level. Similar as for the environmental attribute, the findings of the pilot survey led to re-specifying the loss and damage attribute. On the one hand, respondents expressed issues with regards to understanding a percentage-change with regards to a reference point. On the other hand, the coefficient found in a basic MNL model

on the pilot data indicated that the attribute was over-specified (i.e. attribute levels to wide). Therefore, the loss and damage attribute was rephrased into absolute terms and the levels were narrowed down. To address the stated issue with regards to the lack of a reference point, the respondents were provided with a cognitive calibration point of existing numbers in practice. This was done by displaying an output table (appendix: table A) containing a frequency distribution on loss and damage per mode found in the Dutch VOT study in the Netherlands 2003/2004 (de Jong et al., 2004) prior to the choice tasks but after gaining the reference data on the typical transports.

Figures 12 and 13 are two examples of choice tasks from the final SP survey of the within-mode and between-mode respectively. One is given for an ingoing typical transport, whereas the other is given for an outgoing typical transport.

Figure 12: Example CT for WM ingoing typical transport flow

Ingoing: CT X

Suppose you can choose between the following 3 alternatives for an ingoing typical transport flow to your company
The mode of transport 1, 2 and 3 is identical to your mode in practice for a typical ingoing transport flow

	Transport 1	Transport 2	Transport 3
Transport Time (door to door, days)	2.4	4.05	3
Price (EURO)	13750	12500	11250
CO_2 in g/tonne-km	30	40	50
Option	**A**	**B**	**C**

Which option do you choose?

Figure 13: Example CT for BM outgoing typical transport flow

Outgoing: Choice Task X

Suppose you can choose between the following alternatives for an outgoing typical transport flow from your company

	Road	Rail	Inland Waterways	Short Sea Shipping
Transport Time (door to door, days)	1.63	2.04	2.76	2.04
Price (EURO)	900	1200	1500	1200
Loss & Damage: % of total cargo	8%	2%	0.02%	2%
CO_2 in g/tonne-km	50	50	20	40
Reliability: % arriving on time	98%	80%	85%	75%
Option	**A**	**B**	**C**	**D**

Which option do you choose?

An overview of the attributes used in the final SP survey is given in Table 8 below. It is emphasised that the selection of the attributes was based upon review of the freight mode choice literature (see Table 1 in chapter 2), as well as based on conventional value-of-time studies in the freight literature (de Jong et al., 2014) and the specific focus of this application on the role of the environment. In addition, formal and informal conversations with personnel at the Port of Ghent Authority also guided to shape the choice of attributes, attribute phrasing and attribute levels. The motivation to pivot the cost and time attribute was applied to increase the *"realism*" of the SP survey but is also required to deal with the distance heterogeneity present in the identified population of ingoing and outgoing typical transport flows across shipper companies. This is because the Port of Ghent not only acts as a destination point for ingoing freight transport flows, but also as a point of origin for outgoing freight transport flows.

Due to the sample size obtained, it was opted to keep the observations from the pilot survey and merge them with the observations obtained from the final survey to allow for model estimation, especially with regards to more complex models. The differences between the pilot and final SP surveys are accounted for in the choice modelling by using a scale parameter. Similarly, another scale parameter is used to combine the choice observations coming from both the WM as well as BM choice tasks. This will be highlighted in the chapter on the choice model results (5.1).

Table 8: Overview of attributes with levels used in the SP survey (final)

Attributes	WM	BM	Pivot	Description	Levels
Transport Time	X	X	X	door-to-door in days	-20% -10% 0% +20% +35%
Transport Cost	X	X	X	tariff price in euro	-25% -10% 0% +10% +25%
Loss & Damage		X		% of total cargo	0.02% 0.5% 2% 5% 8%
Reliability		X		% arriving on time	75% 80% 85% 90% 98%
CO_2 emissions	X	X		g/tonne-km	20 30 40 50 60

4.4.2.2 Statistical Design of the SP survey

The SP survey uses D-efficient designs following the work of Rose and Bliemer (2009). The Ngene software was used to compute the WM and BM designs (Choice Metrics, 2014), of which the code can be consulted in appendix (table B). The pilot version ran with seven companies in spring 2016. MNL models were estimated on the pilot data which provided new priors that were fed back into the statistical design.

The pilot as well as final design were based upon the following utility functions for the within-mode choice tasks:

$$\begin{aligned} U_{T1} &= \beta_{TC}.TC_{T1} + \beta_{TT}.TT_{T1} + \beta_{ENV}.ENV_{T1} + \varepsilon_{T1} \\ U_{T2} &= ASC_{T2} + \beta_{TC}.TC_{T2} + \beta_{TT}.TT_{T2} + \beta_{ENV}.ENV_{T2} + \varepsilon_{T2} \\ U_{T3} &= ASC_{T3} + \beta_{TC}.TC_{T3} + \beta_{TT}.TT_{T3} + \beta_{ENV}.ENV_{T3} + \varepsilon_{T3} \end{aligned}$$

For the between-mode choice tasks, the utility functions took the form of:

$$\begin{aligned} U_{ROAD} &= \beta_{TC}.TC_{ROAD} + \beta_{TT}.TT_{ROAD} + \beta_{LD}.LD_{ROAD} + \beta_{ENV}.ENV_{ROAD} \\ &\quad + \beta_{RL}.RL_{ROAD} + \varepsilon_{ROAD} \\ U_{RAIL} &= ASC_{RAIL} + \beta_{TC}.TC_{RAIL} + \beta_{TT}.TT_{RAIL} + \beta_{LD}.LD_{RAIL} + \beta_{ENV}.ENV_{RAIL} \\ &\quad + \beta_{RL}.RL_{RAIL} + \varepsilon_{RAIL} \\ U_{IWW} &= ASC_{IWW} + \beta_{TC}.TC_{IWW} + \beta_{TT}.TT_{IWW} + \beta_{LD}.LD_{IWW} + \beta_{ENV}.ENV_{IWW} \\ &\quad + \beta_{RL}.RL_{IWW} + \varepsilon_{IWW} \\ U_{SSS} &= ASC_{SSS} + \beta_{TC}.TC_{SSS} + \beta_{TT}.TT_{SSS} + \beta_{LD}.LD_{SSS} + \beta_{ENV}.ENV_{SSS} + \beta_{RL}.RL_{SSS} + \varepsilon_{SSS} \end{aligned}$$

These utility functions used for the SP designs are rather basic compared to the utility functions described in the methodology chapter. This is because the form of the utility functions cannot be known exactly prior to the modelling stages. In addition, the original motives were mainly to estimate MNL models. However, it needs to be noted that Bliemer and Rose (2011) argue to align the utility functions used in the design as closely as possible to the model which will be estimated upon the data. The utility functions used for the designs are specified for MNL modelling with all attributes linear and all parameters generic across respondents. It was opted to keep the parameters generic after the pilot as well and thus not to include differences due to different behavioural assumptions across respondents.

The priors used for the different attributes in the pilot designs were derived from existing literature. Values were extracted from the different papers displayed in Table 2 (see chapter

2). However, these values from literature were reported in different quantities and units of measure. Therefore, the values were converted to a unified unit of measure (EUR/tonne). Three bounds per type of design were tested to examine the effect on the D-error value. The D-error gives an interpretation to the level of efficiency of the design. The lower the value is, the more efficient the design is (Rose and Bliemer 2009). The first bound consisted of the minimum and maximum values derived from the literature. The second and third bound consisted of two enlargements of the min-max range. These were used both for the designs of the within-mode and between-mode choice tasks. The overview is provided in Table 9.

Table 9: Bounds of priors used in the pilot SP design

WM	B_{TC}			B_{TT}			B_{ENV}	MNL D-ERROR	Chosen for pilot
min-max lit	u	-4	0.0000000083	u	-0.48	-0.0055	u,-1,0	0.585435	**Y**
Widening 1	u	-4.5	0.00000080	u	-0.98	-5.5E-05	u,-1,0	0.587956	N
Widening 2	u	-5	0.00008	u	-1.3	-5.5E-07	u,-1,0	computational issue	N

BM	B_{TC}			B_{TT}			B_{LD}			B_{ENV}	B_{RL}			MNL D-ERROR	CFP
min-max lit	u	-4	0.8E-07	u	-0.48	-5.5E-04	u	-14.65	-0.408	u,-1,0	u	0.089	0.145	0.723813	**Y**
W1	u	-4.5	0.8E-06	u	-0.98	-5.5E-05	u	-15	-0.2	u,-1,0	u	0.001	0.2	0.724198	N
W2	u	-5	0.8E-064	u	-1.3	-5.5E-07	u	-15.5	-0.01	u,-1,0	u	1E-05	0.5	0.72195	N

In terms of choosing which distribution to apply to the priors in the pilot designs, it was opted to follow Kessels et al. (2006) and use a uniform distribution. This is indicated in Table 9 with "u". It should be noted that for the environmental attribute, reported coefficients in freight transport DCM literature are scarce. Up to the knowledge of the researcher, only three papers report on a GHG coefficient. The paper of Nugroho et al. (2016) and both collaborations of Nikolaus Fries as the main author. As the paper of Nugroho does not report on a willingness to pay measure, the work of Fries et al. (2009,2010) is taken as benchmark. The journal article reports a value of -0.451 for the MMNL and -0.297 for the MNL model (Fries et al., 2010). The conference paper which includes more interactions (distance, good types) effects in the model

reports a value of -0.463 (MMNL) (Fries et al., 2009). Therefore, a uniform distribution between -1 and 0 seems appropriate as both reported results are close to -0.5.

Both for the within-mode choice tasks pilot design as for between mode choice tasks pilot design, it was opted to use the min-max range derived from the literature for the prior values. In the case for the within design, it yields a slightly better D-error. In the case for the between design, the amelioration in D-error from the min-max to W2 (widening 2) is of a magnitude that can be neglected. By using the min-max range or in other words by setting the prior range wide: extensive models in terms of attributes (including seven or more attributes) as well as smaller models (including three to five attributes) across literature are accounted for.

To end the design process, the initial pilot MNL coefficient results were used as priors to derive the final designs for the within-mode and between-mode choice tasks (as is in line with the d-efficient design literature following Rose and Bliemer (2009)). However, it was opted to use the coefficient found from the within-mode pilot sample model as a prior for the two designs (within-mode and between-mode) for the environmental attribute. This was done as the MNL coefficient found for the environmental attribute (0,003) in the between-mode pilot sample did not result of the expected sign, nor fell into the interval which was used to derive the initial design (based upon the literature). The priors used for the utility functions in the two types of designs are listed in Table 10.

Table 10: Priors used in designs final SP's

	B_{TC}	B_{TT}	B_{ENV}	B_{RL}	B_{LD}
Within-mode	-0.006	-0.157	-0.713	NA	NA
Between-mode	-0.008	-0.0003	-0.713	3.955	-1.123

The pilot MNLs, each for the within-mode and between-mode selection of the pilot sample can be consulted in Appendix (tables C and D). The next section will elaborate on the attitudinal questionnaire.

4.4.3. The QN components of the survey: attitudinal

The second part of the quantitative data collected consisted of environmental attitudinal data. This was collected in the form of statements using a 6-point Likert Scale.

The use of Likert Scaling to assess attitudinal statements is widely established across disciplines since the origin work of Likert in 1932, where the author initiated the technique to measure attitudes (Likert, 1932). The use of a 6-point Likert Scale for this study is motivated by the information it provides on the direction of the middle, however, it does not allow for a status quo position. It needs to be noted that a Likert Scale using a 5- or 7-point scale is more typical and widely spread. However, Garland (1991) argues that using an even Likert Scale minimises the social desirability bias (i.e. pleasing the interviewer, answering according to perceived socially correctness). The debate whether to use an un-even or even Likert Scale is beyond the scope of this doctoral research, however, it is acknowledged that there is significant support for an uneven Likert scale.

Environmental attitudinal statements were specified both on the individual levels as well as on the corporate level.

Statements formulated on the individual level were based upon topics identified from passenger mode choice studies using both scales of "agreement" as for example in Bahamonde-Birke and Ortuzar (2015), Bahamonde-Birke and Hanappi (2015), Bahamonde-Birke et al. (2015), Hess et al. (2013) as well as scales of problem evaluation as for example used in Daziano and Bolduc (2013). The identified topics which were used to form the environmental statements in this research are: ecological awareness, ecological consumption (carbon footprint), environmental protection, the growth paradigm, environmental scepticism, energy use, air pollution and road pricing.

It could be derived that examples of environmental attitudinal statements were easily available in the passenger mode choice literature. This was not the case for environmental statements formulated on a corporate level. As such, the development of these statements was more explorative of nature. Up to the knowledge of the researcher, no attitudinal surveys

in freight transport research that take the perceived company environmental outlook are available. Therefore, the corporate attitudinal questions were developed with the help of stake-holder group analysis. The following stakeholders were identified: clients, shareholders, employees, potential employees and the local community. Environmentally orientated statements were formulated based upon each stakeholder group. In addition, to avoid response trend and cognitive laziness of the respondent, the statements were balanced in terms of positive or negative formulation across the different stakeholder groups.

All statements can be consulted in the appendix (9.3), however, only one version is included as the order of the statements was randomised.

4.5 Reflection

The data collection survey design aimed at integrated both qualitative interviews and quantitative stated preferences choice tasks as well as attitudinal statements applying a Likert Scale. The integrated survey design follows out of the mixed methods methodological design with quantitative priority. A pilot of the survey ran with seven companies and insights derived on the initial MNL model results as well as relevant given feedback by the respondents was used to finetune it. This implied an adjustment in the levels of the loss and damage attribute as well as giving European reference data on loss and damage frequencies and average CO_2 emissions across modes prior to commencing the choice tasks. This is addressed in the models by using a scale parameter to account for the potential differences in variances of the error terms between the data-sets.

It needs to be noted that there is a potential risk of response bias when integrating both qualitative interview questions before and after the stated preference choice tasks. However, this potential effect on the choice tasks was minimised by applying a strict interview protocol, which set a specific order for the interview questions as well as listing the formulated questions and potential probe questions. It needs to be repeated that the questions asked before the stated preference choice tasks did not push for or ask on any specific attributes as

used in the SP nor referred to specific factors which might influence decision-making in practice. It simply stated to describe the given situation. The qualitative questions with regards to the perceived *"realism"* of the SP survey were asked after completion of all the choice tasks. In addition, the interviewer asked the interviewee to reflect back on given comments during the choice tasks which lead to interesting insights and are described in results chapter two (5.2). The last qualitative interview question shifted the emphasis on the modal shift in the regional context of the Port of Ghent. Throughout the collection process, the role of the interviewer (in this case the researcher) was to assist the respondents during the choice tasks and give clarification if needed and follow the qualitative interview protocol. It was not to guide the answers given by the respondents.

The research application was confronted with certain limitations during the data collection efforts that can be attributed to the corporate nature of the targeted decision-makers. This is not only relevant to this application but is observed in other freight SP studies as well. For example, the study of Beuthe and Bouffioux (2008) also with Belgian shippers mentions the difficulty to attain a large dataset. It was noted during the collection phase that the specific cost value required for the pivot design of the SP acted as the main barrier to agree to participate in the given survey. This confirms the sensitive and competitive nature of company data. In addition, a second barrier that was noted were the strict time schedules of the logistics managers. Often meetings were rescheduled or even cancelled. It needs to be acknowledged that indeed the time requirement of one hour to conduct the data collection is sizeable. However, multiple data collection efforts were undertaken with support of the Port of Ghent Authority. All contact emails could be sent out to the companies using an official Port of Ghent email assigned to the researcher. The emails were addressed (if possible) to the specific CEOs and logistics managers using the contact list as provided by the Port of Ghent. In addition, a support letter signed by the CEO of the 'Port of Ghent Authority' and (former) chairman of the employer's organisation 'Flanders' Chamber of Commerce and Industry - region East-Flanders' ("VOKA") was added to introduce the researcher and the research. A second round included sending the letter by post to the CEO's of the targeted companies.

The data was collected during an interesting time of change for the Port of Ghent region. During that time the future merge with the port authorities of Vlissingen and Terneuzen

(Zeeland Seaports) in the Netherlands became tangible. Therefore, additional data gathering was sought in light of this merge in summer 2017. Co-operation with the CEO of Zeeland Seaports was established, who co-signed the information letter. This was sent by email to the provided Zeeland Seaports business contacts. 60 companies were identified to be relevant for the study and targeted. Unfortunately, the response rate was extremely low. Only three companies responded, of which two declined and one participated. This could be due to the bad timing of the study (just in the middle of the ongoing merging of the port areas or merely summer time), disinterest or issues with the provided contact list. Further target attempts were not undertaken in light of the time constraints of the PhD program. The data coming from the only participating Dutch firm was disregarded for the analysis.

As a side note, it can be stated that the described collection efforts were all without financial incentives for the participants and the survey was not funded by a large institutional body. In addition, the University of Leeds sets out strict regulations with regards to research ethics. An ethical review was completed and approved (Code: AREA 14-110), with an extension of the timeline to collect the data. In addition, a risk assessment was successfully accepted by the university. The participants were made aware of the ethical review and were asked to sign a participant consent form at the start of each meeting. The consent form informed the participants about the usage of their data, anonymity of the data by aggregation and asked for their consent to record the entire meeting on tape.

Despite the low participation rate resulting in a smaller sample size than aimed for, the efforts resulted in 600 choice observations which could be merged into one dataset for choice modelling purposes and in-depth interview data both on mode choice in practice as well as on the topic of modal shift for thematic analysis purposes.

5. Results Chapters

5.1 Introduction

The result chapters are built around the three main thematic sets of research questions which were described in the introduction chapter. These are: mode choice, SP validation and modal shift. The research questions were also grouped according to specific techniques applied to best answer these (Figure 4, Chapter one). Namely, either by quantitative methods, qualitative methods or integrating the two techniques.

The first results chapter (5.2) is focused on the research questions around freight mode choice with a quantitative orientation (RQ1.A, RQ1.B and RQ1C). In particular the impact of transport time, transport cost (tariff), loss and damage, reliability, CO_2 emission and environmental attitudes on logistic manager's preferences with regards to freight mode choice are studied. As discussed in the methodology chapter, these questions are addressed using choice modelling techniques. In particular, the multinomial logit (MNL), mixed multinomial logit with random taste heterogeneity (MMNL) and integrated choice and latent variable (ICLV) models are applied. The first results chapter is structured according to these different models. It needs to be noted that choice models are increasingly built by adding complexity in a step-by-step manner. Also in this thesis, the models build upon each other and model results from previously tested modelling techniques are used as starting-base to expand to the next model.

First, the MNL model results are given accompanied by the relevant policy measures derived from the modelling results (section 5.2.2). Next the MMNL results are shown, also accompanied by the relevant derived policy measures (section 5.2.3). Thirdly, the results of the ICLV models which accounts for underlying environmental attitudes are given. This includes a model only using one latent variable as well as a model using two latent variables to address the potential duality between personal and corporate perceived environmental attitudes (section 5.2.4). The fourth section contains comparisons between the different models with regards to the estimation output, goodness of fit criteria and comparing the

relevant policy measures that were derived (section 5.2.5). At the end of this chapter, a reflection is provided.

The second results chapter (5.3) is built around two main components of the research which relate to the concept of integration in the mixed methods design, namely integrating qualitative and quantitative findings. The first component relates to the contextual setting as perceived by the respondents in which the freight mode choices are made in practice (RQ1.D. and RQ1.E.). Integration of QL and QN takes place at the interpretation phase by drawing insights from combining predominantly qualitative findings with supporting choice model results. The second component is on the research questions with regards to the perceived *"realism"* and participants' experiences of the freight SP survey (RQ2.1, RQ2.2). It combines both the findings from the choice models with findings from the qualitative analysis to derive insights relating to the freight SP survey. It can be argued that this form of integration takes place at the interpretation phase of the research process. In addition, integration also takes place at the analysis phase, in which an overview of the results of the explorative modelling process of combining both quantitative mode choice and quantified qualitative themes is given.

The second results chapter is structured as follows. Firstly, the general structure of the thematic analysis output will be briefly highlighted in order to relate the qualitative findings to on the one hand, the choice model estimation results and on the other hand, relating them to the topic of mode choice in practice (section 5.3.2). Secondly, insights on the participants' experiences with regards to the stated preferences survey will be highlighted according to the choice tasks, attributes and perceived differences between the labelled and unlabelled setting for example in terms of difficulty to complete (section 5.3.3). The chapter will also include a reflection on why a perspective from the logistics managers is taken (section 5.3.4). Lastly, the second results chapter will discuss the model efforts that were made to explore on the incorporation of a subset of the derived qualitative themes into an ICLV model (section 5.3.5).

The third results chapter (5.4) deals with the set of research questions around the modal shift topic (RQ3.1, RQ3.2). It differs from the previous two results chapters, since it has a main qualitative orientation. The third results chapter is structured as follows. The perceived barriers and triggers of a modal shift in the regional context of the Port of Ghent are highlighted in section 5.4.2. These qualitative derived insights will be related to three logistical trends as described in the literature (section 5.4.3). The third results chapter will end with a reflection.

5.2. Results Chapter one: Factors influencing mode choice (QN)

5.2.1. Introduction

Results chapter one will report on the model findings with regards to on the one hand, the impact of transport time, transport cost (tariff), loss and damage, reliability and CO_2 emissions and on the other hand, the impact of environmental attitudes on mode choice.

Section 5.2.2 reports on the multinomial logit model results, followed by section 5.2.3. which includes the results of the mixed multinomial logit model with random taste heterogeneity. The impact of environmental attitudes is addressed in section 5.2.4. in which the integrated choice and latent variable model results are given. Next, comparisons between the models are made in terms of goodness of fit measures and the derived policy measures from the MNL and MMNL model results. The chapter ends with a short reflection on the model results which sets the tone for the discussion chapter.

5.2.2. MNL

5.2.2.1. Mode Choice

Table 10 presents the estimation results with regards to the impact of transport time, transport cost (tariff), loss and damage, reliability and CO_2 emissions of the multinomial logit model. It needs to be repeated that the models are based upon 600 choice observations, with 20 decision-makers (32 choice tasks per respondent, with some non-completed). The MNL model recognised the panel-data nature (repeated choice tasks), by carrying out all integration at the level of the individual respondent. The t-ratio indicates the estimated coefficient divided by its standard error. The robust t-ratio that is reported differs from the t-ratio as it corrects for model misspecification (see Daly and Hess (2010)).

As described in the methodology chapter, two different specifications with regards to the cost and time attribute were tested. Both the conventionally used linear as well as a non-linear logarithmic specification were used. This was tested as the cost attribute showed a large dispersion between the minimum and maximum value, which can result in issues of

scale. In addition, it follows from the work of Rotaris et al. (2012) who advocate that the assumption of linear attribute coefficients should be rejected in the freight choice literature. However, in Rotaris et al. (2012) additionally to the cost and time attributes, non-linearity is also used for the loss and damage as well as for the punctuality attributes. This application looks at non-linearity for the coefficients of the cost and time attributes, but not loss and damage or reliability attributes. The model which uses a logarithmic specification only for the transport cost attribute was found to perform best based upon the likelihood ratio test(***), Akaike information criterion and Bayesian information criteria. These statistical measures will be elaborated upon in the section on goodness of fit measures (section 5.2.5.1). The estimation results for the model only using linear specifications of the attributes is provided in appendix for reference to the reader (Table E). The model with logarithmic specification for the transport time attribute did not result in a stable model.

In addition, two scale parameters with a fixed scale base (of value one) were introduced to account for the differences in the variances of the error terms between the different data-sets: between the pilot and final SP survey choice data as well as between the within-mode and between-mode choice tasks. As the scale base is set to the value of one, the model estimates need to be interpreted based on the t-ratio and robust t-ratio against one. This is indicated in the table by using an “a” in superscript. Both scale multiplier estimates are found to have a value different from one, however, only the scale parameter controlling for the differences between the within-mode and between-mode choice tasks is found significant. This indicates that there is no significant found differences in the variance of error terms between the within-mode and between mode datasets and that the model picked up on some differences in the variances of the error terms between the pilot and final SP survey choice data.

ASC 1 and ASC 2 indicate the alternative specific constants from the utility functions specified for the within-mode choices, namely the left and middle alternatives (relative to the right alternative). Road, rail and iww indicate the alternative specific constants for the road, rail and inland waterway (IWW) main mode respectively in the between-mode choices. Only ASC2 is found significant based both on the t-ratio as well as robust t-ratio. Indicating thus a slight effect of choosing away from the middle alternative.

The coefficient estimation results of the attributes are all of the expected sign according to the mode choice literature and all attribute coefficients (except the loss and damage coefficient) are found significant. Two particularities stand out. Firstly, the estimate of the reliability attribute coefficient is found rather large, implying that (ceteris paribus) an improvement of the reliability of a typical shipment has a significant strong positive effect on the utility of that alternative and thus on the likelihood of that alternative being chosen. However, such interpretation needs to made based in relation to the derived willingness-to-pay measures. Secondly, the estimate of the environmental attribute is only found significant based upon the robust t-ratios and not on the t-ratio. As the loss and damage coefficient was not found significant, it might indicate that the decision-maker did not take it into account when making the freight mode choices. This will be further addressed in the second results chapter (5.3), which brings together qualitative insights on the participants experiences with the SP survey.

Table 10: MNL model output

	MNL		
	estimate	t-ratio	Rob. t-ratio
ASCs:			
asc1	-0.1400	**-2.06**	-1.71
asc2	-0.1852	**-2.76**	**-3.48**
road	0.3765	**2.03**	1.69
rail	0.0174	0.09	0.07
iww	0.1948	1.03	0.90
Attributes:			
transport time	-0.0695	**-5.61**	**-3.71**
transport log(cost)	-2.8173	**-8.03**	**-4.51**
CO2 emissions *DT*TN	-0.0236	-1.35	**-2.1**
loss and damage	-1.0121	-1.56	-0.57
reliability	6.1490	**7.48**	**4.43**
Scaling parameters:			
scale_base	1.0000	NA	NA
scale_multiplier_WITH	2.9588	**3.32**[a]	**2.45**[a]
scale_multiplier_FINAL	1.3917	1.39[a]	1.20[a]
LL(0)	-744.32		
LL(final)	-460.53		
Estimated parameters	12		
AIC	945.06		
BIC	997.82		
Estimation time (hh:mm:ss)	00:00:14.88		

[a]t-ratio and robust t-ratio against 1

The next section reports on the derived willingness-to-pay measures based upon the MNL estimation results.

5.2.2.2. Policy Measures

One of the main output results of choice models are the sensitivity measures or willingness-to-pay measures which are derived from the estimation results, for example with the value of time (VOT) being one of the most popular derived outputs. These outputs are argued to be relevant to the policy-level as they can be applied in cost-benefit analysis (for example for a transport system planning project) or serve as input values (amongst other input-variables) for traffic forecasting models (Shires and de Jong, 2009). The willingness-to-pay (WTP) measure is the amount of money that an individual would pay for an improvement of one unit of the considered attribute. It is conventionally derived by (assuming linear specification of the utility function U in the parameters):

$$WTP_{ATTRIBUTE} = \frac{\frac{\partial U}{\partial ATTRIBUTE}}{\frac{\partial U}{\partial TC}} = \frac{\beta_{ATTRIBUTE}}{\beta_{TC}} \qquad (1)$$

Or put differently, the marginal utility of an attribute divided by the marginal utility of the transport cost (tariff) attribute. However, the utility function used in the MNL model applies a logarithmic specification in the transport cost (tariff) attribute. Therefore, the mean reference cost across all choice tasks needs to be added:

$$WTP_{ATTRIBUTE} = \frac{\beta_{ATTRIBUTE}}{\beta_{TC}} . MEANCOST \qquad (2)$$

The estimates of the time, reliability and environmental attributes were found significant on the robust t-ratio. However, for completeness the value of loss and damage will also be reported even though the attribute was not found significant. The VOT is both reported for days as well as for hours for a typical transport.

The derived VOT indicates that individuals are willing to pay 3.95 EUR for a decrease of one day in the transport time of a typical transport. Likewise, they are willing to pay 0.16 EUR per hour to reduce the transport time per typical shipment. The VOR measure needs to be interpreted as follows: individuals are willing to pay 3.49 EUR for an increase of 1% in

reliability in terms of % arriving on time. A WTP of 1.34 EUR for a reduction of one ton CO_2 emissions was found.

The MNL derived WTPs will be compared to those based on the MMNL estimation results and will be put in the context of the reported results in the literature (section 5.2.5.2).

Table 12: Willingness-to-pay measures (MNL)

WTPs (EUR)	
VOT (day)	3.95
VOT (hour)	0.16
VOR (1% increase)	3.49
VO_ENV (1ton CO_2 emissions)	1.34
VO_LD (1% decrease)	41.51
Choice observations	600

5.2.3. MMNL

The MNL model assumes that every decision-maker has the same taste preference with regards to time, cost (tariff), loss and damage, reliability and CO_2 emissions. This assumption implies that all the logistics managers in the shipper's companies in the case-study population are assumed to behave homogeneously. This does not seem very convincing or even plausible when considering the variety across the companies in terms of range of products, specific production processes, different inventory capacities etc., that collectively shapes the particular value-added nature of the Port of Ghent. In addition, the freight mode choice literature reports on different preferences with regards to the time and cost attributes, mostly in relation to different market segments (e.g. see the study of Arunotayanun and Polak (2011)). However, as the sample size of this study does not allow to differentiate across market segments it is opted to build further upon the MNL model results and add model complexity by allowing for random taste heterogeneity in the attributes. These model tests will be discussed in the following section which gives the estimation results of the mixed multinomial logit with random taste heterogeneity.

5.2.3.1 Mode choice

The mixed logit builds further on the multinomial logit model and keeps the logarithmic specification for the cost attribute. It differs from the MNL model in the sense that it allows for taste heterogeneity across the decision-makers in selected attributes by introducing additional random components which follow a distribution set by the researcher. As described in the methodology chapter, two conventionally used distributions were tested for the parameters of the additional random components: a Normal distribution (with mean zero) and a (negative) Lognormal distribution. The model using a (negative) Lognormal distribution was found to behave best in terms of significant effects and based on the LR test(***). For the readers reference, the MMNL model using Normal draws is added in Appendix (table F).

Allowing for random taste heterogeneity across decision-makers was tested increasingly in all the attributes (see table G in Appendix for the model in all attributes). The model allowing for random taste heterogeneity in the transport time, transport cost (tariff) and environmental attribute was found to work best (based on LR test, AIC, BIC and significance of effects).

The models were first simulated with 200 Halton draws and checked for stability by increasing the number of draws up to 1000.

The result of the mixed multinomial logit model allowing for random taste heterogeneity in the transport cost (tariff), transport time and environmental attribute parameters, using a (negative) Lognormal distribution for the random components (mu and sigma's, see methodology chapter) and 1000 Halton draws is given in Table 13. However, as the mu's and sigma's are coded in R within a negative exponential, the estimates are not directly interpretable and need to be converted (as for example in Hess et al. (2005)). For example, with regards to the random parameters of the transport cost (tariff) attribute, these become:

$$TC\_mu = -\exp(\log \_TC\_mu + \log \_TC\_sigma^2/2)$$

$$TC\_sigma = TC\_mu \,.\sqrt{\exp(\log \_TC\_sigma^2) - 1}$$

The interpretable converted coefficients are given in Table 14.

Looking at the mixed logit estimation results (Table 13), the same interpretation as in the MNL model estimation result holds for ASC2 as well as for the scale parameter that indicates no significant differences between the variance of the error terms between the within-mode and between-mode datasets. However, the result with regards to the scale parameters only holds based on the t-ratio (against 1) and not on the robust t-ratio (against 1).

In terms of the attributes and as in the MNL, the estimate of the loss and damage attribute coefficient is not found significant and the reliability coefficient estimate remains high and significant.

The transport time, transport cost (tariff) and CO_2 parameters will be discussed based on converted coefficients (Table 14). The mean transport cost, transport time and CO_2 coefficients are found significant and are of the expected sign. Compared to the MNL model results for these attributes, the mean values are a bit smaller which indicates that the MNL slightly overestimated the coefficients. However, only the standard deviation (sigma) of the transport cost is found significant. Based on these model results, it can be concluded that there is only taste heterogeneity across the decision-makers with respect to the cost attribute. This means that the respondents have different taste preferences compared to each other with regards to cost. Unfortunately, the data-set does not allow to explore further on this taste heterogeneity in terms of linking it to different market segments or commodity type due to sample size limitations (segmentation approach or latent class modelling).

The next section will report on the derived willingness-to-pay measures based upon these MMNL model estimate results.

Table 13: MMNL model output

	MMNL h(beta TC,TT,ENV) 1000Halton		
	estimate	t-ratio	Rob. t-ratio
ASCs:			
asc1	-0.1407	**-2.16**	-1.76
asc2	-0.1732	**-2.66**	**-2.85**
road	0.3629	1.91	1.59
rail	0.0062	0.03	0.02
iww	0.1711	0.88	0.78
Attributes:			
logN_mu transport time	-2.6773	**-7.29**	**-6.79**
logN_sigma transport time	0.9112	**2.7**	**2.94**
logN_mu transport cost	1.0781	**6.55**	**4.44**
logN_sigma transport cost	-0.4929	**-3.78**	**-4.52**
logN_mu CO2 emissions	-3.5096	**-4.87**	**-8.16**
logN_sigma CO2 emissions	0.0650	0.07	0.71
loss and damage	-1.0917	-1.62	-0.57
reliability	6.5335	**7.51**	**4.39**
Scaling parameters:			
scale_base	1	NA	NA
scale_multiplier_WITH	2.8369	**2.47**[a]	1.54[a]
scale_multiplier_FINAL	1.7373	1.38[a]	1.01[a]
LL(choice model)	-446.77		
Estimated parameters	15		
AIC	923.87		
BIC	989.5		
Estimation time (hh:mm:ss)	00:08:18.69		

[a]t-ratio and robust t-ratio against 1

Table 14: interpretable coefficients TT, TC and CO2 emissions (MMNL)

Conversion coefficients:	estimate	rob s.e.	rob t-ratio
mu transport time	-0.1041	0.05	**2.06**
sigma transport time	0.1184	0.10	1.14
mu transport cost	-3.3187	0.83	**4.02**
sigma transport cost	1.7404	0.68	**2.58**
mu CO2 emissions	-0.0300	0.01	**2.32**
sigma CO2 emissions	0.0020	0.00	0.67

5.2.3.2 Policy measures

As the interpretation of the MMNL model estimation results needed extra attention with regards to the coefficients, so does the WTP derivation based upon those coefficients. To repeat, the taste coefficients of the time, cost (tariff) and environmental attributes include random components that are set to follow (negative) Lognormal distributions. As Axhausen et al. (2005) and Hess et al. (2005) argue, the choice of distribution (or *"distributional assumption*") can have a significant impact on the model estimation results and therefore also on the derived willingness-to-pay measures. Following again the applied formula as in Hess et al. (2005), the example is given with regards to the time attribute to derive the VOT. However, the same approach is used for the WTP for the environment (VO_ENV):

$$\log\_VOT\_mu = \log\_TT\_mu - \log\_TC\_mu$$

$$\log\_VOT\_sigma = \sqrt{\log\_sigma\_TT^2 + \log\_\mathrm{TC}\_\mathrm{sigma}^2}$$

$$VOT\_mu = -\exp\left(\log\_VOT\_mu + \log\_VOT\_sigma^2/2\right) . MEANCOST$$

$$VOT\_sigma = VOT\_mu . \sqrt{\exp(\log\_VOT\_sigma^2) - 1}$$

Just like in the MNL WTP derivations, the mean cost across choice tasks needs to be added. With regards to the calculation of the willingness-to-pay measures for loss and damage and reliability (VOLD, VOR), the implied logarithm is first taken from the estimation result and then used in the WTP calculations. For example, for loss and damage we have:

$$\log\_LD\_mu_* = \log\left(|LD\_mu|\right)$$

$$\log\_LD\_sigma = 0$$

$$\log\_VOLD\_mu = \log\_LD\_mu_* - \log\_TC\_mu$$

$$\log\_VOLD\_sigma = \sqrt{\log\_\mathrm{TC}\_\mathrm{sigma}^2}$$

$$VOLD\_mu = -\exp\left(\log\_VOT\_mu + \log\_VOT\_sigma^2/2\right) . MEANCOST$$

$$VOLD\_sigma = VOLD\_mu . \sqrt{\exp(\log\_VOLD\_sigma^2) - 1}$$

The derived WTP's are reported in Table 15. Similar to the MNL output, for completeness the VOLD will be included, even though the coefficient was not found significant in estimation result.

Table 15: Willingness-to-pay measures (MMNL)

WTPs (EUR)	
VOT (day)	6.40
VOT (hour)	0.27
VOR (1% increase)	4.02
VO_ENV (1 ton CO_2 emissions)	1.84
VO_LD (1% decrease)	67.13
observations	600

The derived VOT based on the MMNL model results for all the transport flows indicates that individuals are willing to pay 6.4 EUR for a decrease of one day in the transport time of a typical transport. Per hour this comes down to 0.27 EUR. The VOR indicates that individuals are willing to pay 4.02 EUR for an increase of 1% in reliability in terms of percentage of the typical transports arriving on time. A WTP of 1.84 EUR for a reduction of one ton of CO2 emissions was found.

These results will be compared with the findings based on the MNL model in section 5.2.5.2. on modal comparisons.

5.2.4. ICLV: environmental attitudes

To address the impact of environmental attitudes upon freight mode choice, an integrated choice and latent variable framework was used.

Many different models were estimated during the modelling process: experimenting with different indicators (out of a total of 23), different specifications for the indicators (continuous vs. binary specification), different types of draws (Halton vs. MLHS), different distributions used for the random components (Normal vs. (negative) Lognormal) and testing for the behavioural assumption of adding two latent variables to asses specific individual or corporate related environmental attitudes. This resulted in the estimation of over 100 models, mostly because of the time-consuming selection process of the indicators. The time-consuming selection process of the indicators relates to the sample size, which was restricted to 18 companies interviewed until spring 2017. The factor analysis on the sample of 18 companies was not found insightful and therefore a trial-and-error process was followed to select the indicators. Each indicator collected in the survey was added on a one-by-one basis to check for plausibility and significance of the results. The outcome of this modelling process was presented at the International Choice Modelling Conference 2017 in Cape Town. After that, two more companies agreed to participate in the survey. The results of the FA with the increased sample size of 20 companies were found more insightful and resulted in a re-assessment of the used indicators.

Unfortunately, it needs to be acknowledged that the model presented at ICMC 2017 at that time -while delivering on significant and interesting effects of the latent variables on environmental attitudes- was not correctly identified. Therefore, an additional round in the modelling process took place to identify the model by testing different socio-demographic and company specific variables in the latent variable equations. These included: gender, age, education, income, years of service, company size, product type. Issues were encountered in terms of stability and acceptable t-ratio's for the identification variables. This is most probably related to the unbalanced dispersion of individuals across the different categories used per variable and the presence of missing values. Simplified, it comes down to not having enough individuals per category. To address this issue, different category specifications (merging of categories) were tested with regards to education, age and years

of service, but were not found to solve the main issue of very large t-ratio's of these specific identification variables. In an additional modelling round, an ICLV model structure which is identified by using the gender variable was found to work best in terms of estimation results.

Two different model structures are presented which are the outcome of the modelling process. On the one hand, a model will be given using (negative) Lognormal distributions for the random parameters and one latent variable to account for environmental attitudes. On the other hand, a model also using (negative) Lognormal distributions for the random parameters, but including two latent variables to test for the behavioural hypothesis that two potential distinct environmental influences might be impacting the mode choice which is made on behalf of the company. One influence relates solely to the environmental attitudes of the individuals themselves, which might be impacting the choice. As the choice is made for the company, the second influence relates to the environmental outlook of the company or corporate attitudes as perceived by the individual, which might influence the freight mode choice.

ICLV: including one latent variable

Table 16 contains the model results of the ICLV containing one latent variable to account for environmental attitudes, with Table 17 listing the converted coefficient estimates for the time, cost and CO_2 emissions attributes.

Table 16: ICLV 1LV model

	Hybrid: Bolduc norm, 200 Halton		
	estimate	t-ratio	rob t-ratio
ASCs:			
asc1	-0.1406	**-2.01**	-1.67
asc2	-0.1871	**-2.67**	**-3.1**
road	0.3215	1.57	1.64
rail	-0.0274	-0.13	-0.1
iww	0.0573	0.26	0.24
Attributes:			
log_mu transport time	-2.9391	**-9.76**	**-8.19**
log_mu transport cost	1.0755	**8.13**	**5.28**
log_mu CO2 emissions	-3.6416	**-4.22**	**-6.68**
loss and damage	-1.0886	-1.56	-0.53
reliability	**6.7630**	**7.66**	**4.38**
Scaling parameters:			
scale_base	1.0000	NA	NA
scale_multiplier_WITH	3.0785	**3.09**[a]	***1.91(**)***[a]
scale_multiplier_FINAL	1.3533	1.14[a]	0.80[a]
Interaction LV - attributes:			
LV – CO2 emissions	1.0675	1.01	1.56
LV - TC	0.4082	**3.55**	**3.43**
LV - TT	-0.5869	**-2.03**	**-2.11**
Interactions LV - modes:			
LV - rail	0.1322	0.58	0.45
LV - IWW	1.0143	**3.53**	**2.51**
LV - SSS	0.4769	1.91	1.39
Interaction LV - Indicator statements:			
Sigma LV - tradeoff ec welfare - green	0.7793	**5.64**	**7.82**
Sigma LV - green on political agenda	0.5446	**4.9**	**6.36**
Zeta LV - tradeoff ec welfare - green	0.4601	**2.17**	1.9
Zeta LV - green on political agenda	0.5793	**3.45**	**2.66**
Sigma LV - green image	0.8976	**6**	**4.33**
Sigma LV - employees (neg)	0.5493	**5.37**	**5.78**
Zeta LV - green image	0.0236	0.09	0.05
Zeta LV- employees (neg)	0.3782	**2.17**	**1.78**
Identification LV:			
gamma_lv_female	0.3061	0.58	0.36

LL(final)	-518.6032
LL(choice model)	-437.9918
Estimated parameters	
AIC	1091.21
BIC	1209.92
Estimation time	00:28:17.53

[a]t-ratio and robust t-ratio against 1

Table 17: interpretable coefficients TT, TC and CO2 emissions (ICLV 1LV)

Conversion coefficients:	estimate	rob s.e.	rob t-rat
mu transport cost	-2.9315	0.39	**7.56**
mu transport time	-0.0529	0.02	**3.32**
mu C02 emissions	-0.0262	0.02	1.16

The model yields significant effects (and of the expected sign) for the cost, time and reliability attribute. The scale multiplier parameter WITH is significantly different from one, indicating no significant differences in the variance of error terms between the within-mode and between-mode datasets, based on the 10% significance level of the robust t-ratio (against one).

The research interest in applying the ICLV framework lies in assessing the impact of environmental attitudes upon freight mode choice. These attitudes are captured by a latent variable. Before looking at the interaction effects of the latent variable with the different attributes and modes it is interesting to get an idea about the direction or interpretation of the latent variable. This can be derived from the zeta's and sigma's in Table 17, in which the zeta (ζ) represents the estimated effect of the latent variable on the indicator and sigma (σ) is reported for the distribution of the error term. As both the zeta's and sigma's consistently have a positive sign, it can be concluded that positive and higher coefficients of the latent variable translate into more environmentally friendly underlying attitudes in the respondents. Or simply put: *"the bigger the greener"*.

The interaction effects of the latent variable with the cost and time attributes are found significant. This indicates that the more environmentally friendly the respondent is, the more sensitive to costs and less sensitive to time he or she is. Intuitively, one would expect

to see a negative sign of the interaction coefficient (LV - cost) as is the case for the interaction between the LV and time attribute.

In terms of the interaction effects of the LV with the different modes, only the interaction effect with the inland waterway mode is found significant and of a positive sign. This indicates that more environmentally friendly respondents are more likely to choose the inland waterway mode. This result is as expected, however, intuitively it would also be expected with regards to the rail mode. As the interaction effect with the rail mode is not found significant, the results imply that in this respect the respondents did not treat the rail mode any different from the road mode. However, European emissions data shows that the rail mode performs best in terms of percentage-share of CO_2 emissions per tonne-km compared to the other modes (EEA, 2017). This will be addressed in the discussion chapter together with the findings of the qualitative analysis.

Gender is used to identify the model with male being the base category and the reported gamma coefficient indicates the effect of gender on the latent variable. The estimate is not found significant. Nevertheless, the model using the gender variable to identify it is preferred to the other tested socio-demographic variables as the corresponding t-ratios are found acceptable in terms of magnitude and the model resulted in insightful model outputs. In addition, fewer issues with regards to model stability were encountered using the gender variable (no missing values and a reasonably balanced dispersion of individuals across the two categories).

The next model will specifically look at the potential dichotomy between personal and corporate environmental attitudes by including two separate latent variables to account for each.

ICLV: including two latent variables

Table 18 displays the model results of the ICLV containing two latent variables to account on the one hand for individual environmental attitudes and on the other hand to account for the perceived corporate environmental outlook. Table 19 lists the corresponding conversed coefficients for the time, cost and CO_2 emissions attributes.

Table 18: ICLV two LV's model

	Hybrid: Bolduc norm, 1000 Halton		
	estimate	t-ratio	rob t-ratio
ASCs:			
asc1	-0.1387	-1.93	-1.67
asc2	-0.1873	**-2.63**	**-2.89**
road	0.3689	1.75	1.54
rail	0.0487	0.19	0.12
iww	0.0979	0.38	0.3
Attributes:			
log_mu transport time	-3.0654	**-8.23**	**-7.02**
log_mu transport cost	1.0994	**7.5**	**4.89**
log_mu CO_2 emissions	-3.6321	**-4.27**	**-10.2**
loss and damage	-1.1116	-1.57	-0.53
reliability	6.7940	**7.62**	**4.47**
Scaling parameters:			
scale_base	1.0000	NA	NA
scale_multiplier_WITH	3.1125	**2.81**[a]	1.67[a]
scale_multiplier_FINAL	1.2963	0.90[a]	0.65[a]
Interaction LVs - attributes:			
LV I – CO_2 emissions	0.647	0.93	1.23
LV I- TC	0.281	0.31	0.43
LV I - TT	0.129	0.84	0.45
LV C – CO_2 emissions	0.3798	**2.91**	***1.85(**)***
LV C- TC	-0.4856	-1.31	-0.99
LV C - TT	-0.3631	-1.06	-0.52
Interactions LV - modes:			
LV I - rail	0.0252	0.1	0.07
LV C - rail	0.164	0.56	0.25
LV I - IWW	0.6751	***1.93***	1.16
LV C - IWW	0.6853	**2.02**	1.12
LV I - SSS	0.5934	**2.05**	***1.9***
LV C - SSS	0.0021	0.01	0
Interaction LVs - Indicator statements:			
Sigma LV I - tradeoff economic welfare - green	0.7799	**5.61**	**4.67**
Sigma LV I - moral obligation	0.5622	**3.64**	**2.77**
Sigma LV I - green on political agenda	0.6467	**5.25**	**5.04**
Sigma LV I - CF consumption	0.5648	**2.49**	1.93
Sigma LV I - efficient road pricing	1.0988	**5.67**	**7.26**
Zeta LV I - tradeoff ec. welfare - green	0.4702	**2.16**	1.58

Zeta LV I - moral obligation	0.8008	**4**	**3.63**
Zeta LV I - green on political agenda	0.4806	**2.56**	**2.93**
Zeta LV I - CF consumption	0.9093	**3.85**	**3.18**
Zeta LV I - efficient road pricing	0.5206	1.76	1.55
Sigma LV C - employees (neg)	0.8731	**5.56**	**4.75**
Sigma LV C- green image	0.5674	**3.99**	1.84
Sigma LV C - high potentials loss	0.5776	**5.83**	**6.67**
Sigma LV C - avoid tax fines	0.5478	**4.42**	**2.37**
Zeta LV C- employees (neg)	-0.2256	-0.64	-0.25
Zeta LV C - green image	0.3432	1.29	0.49
Zeta LV C - high potentials loss	-0.0221	-0.12	-0.06
Zeta LV C - avoid tax fines	0.2905	1.24	0.46
Identification LV:			
gamma_lv_I_female	0.2271	0.45	0.26
gamma_lv_C_female	0.1708	0.25	0.11
LL(final)	-619.2930		
LL(choice model)	-435.4138		
Estimated parameters			
AIC	1326.59		
BIC	1520.05		
Estimation time (hh:mm:ss)	01:40:54.38		

[a]t-ratio and robust t-ratio against 1

Table 19: interpretable coefficients TT, TC and CO2 emissions (ICLV 2LVs)

Conversion coefficients:	estimate	rob s.e.	rob t-rat
mu transport cost	-3.0024	0.44	**6.82**
mu transport time	-0.0466	0.02	**2.69**
mu C02 emissions	-0.0265	0.02	1.18

As for the ICLV model only using one latent variable, the estimates of the transport time, transport cost (tariff) and reliability coefficients are found significant and of the expected sign. The same interpretation with regards to ASC2 holds as well. However, as in the MMNL, the reported significant effect with regards to the WITH scale parameter indicating no significant different in the variance of the error terms between the within-mode and between-mode datasets is not found.

The direction of the latent variable specified on the individual level is interpreted as follows: positive and higher coefficients of the latent variable translate into more environmentally friendly underlying attitudes in the respondents (as the sigma's and zeta's are consistent and of the same (positive) sign). However, with regards to the latent variable specified on the corporate level changing signs can be seen and non-significance of the zeta's can be noted. This would indicate that a higher corporate LV coincides with a less environmentally friendly perceived corporate outlook, yet this was not found significant.

In terms of interaction effects of the two LV's with the attributes, only the interaction of the corporate LV is found significant with the CO_2 emissions attribute, although only on the ten percent significance level for the robust t-ratio (**). Considering also the negative sign of CO_2 emissions coefficient estimate, this would indicate that individuals that perceive their company to be more environmentally friendly are more sensitive towards CO_2 emissions.

Most of the interaction effects of the LV's with the modes which are found significant based upon the t-ratio are not found significant when moving to the robust t-ratio's. Where significant effects were found both for the individual and corporate LV with the inland waterway mode based on the t-ratio, these do not hold based upon the robust t-ratio. However, a significant effect at the ten percent significance level (**) of the individual LV is found with the short sea mode, indicating that more environmentally friendly respondents are more likely to choose the short sea shipping mode. Again, the surprising interpretation of the rail mode still holds where the respondents with an individual green attitude or perceived environmentally orientated company did not treat the rail mode significantly different from the road mode.

Both the identification parameters with gender were found to acceptable t-ratios, however, again not found significant. The same reasoning applies as for the ICLV 1LV model.

However, while the model presented above includes both the LV on the personal level and the LV on the corporate level simultaneously, it assumes that the two LV's are uncorrelated. Potential correlation between the two latent variables was controlled for by introducing a Choleski factor between the random components in the latent variable equation (Train, 2009): $LV_C = \gamma_{CG}.G + CHOL.\eta_I + \eta_C$. However, the model results were not found

sufficient in terms of stability of the coefficient of the Choleski factor. This is probably due to the limited data sample size. The model adding a Choleski factor is presented in Appendix (table H).

5.2.5 Comparison of models

First the model estimation results will be compared, followed by a comparison based upon goodness-of-fit measures (5.2.5.1.) and lastly differences in the derived willingness-to-pay measures will be highlighted (5.2.5.2).

The variables relating to the choice model (ASC's, attribute coefficients and scale parameters) remain consistent in terms of significance and expected signs across the different model structures. However, it needs to be noted that the CO_2 emissions coefficient loses its significance in the ICLV models. From the estimation result for the alternative specific constant of the middle alternative in the unlabelled choice tasks, it became clear that participants were slightly more likely to choose away from the middle alternative. However, the estimated value is rather small. Surprisingly, no significant effect was found for the alternative specific constants relating to the IWW mode nor to the road mode in the labelled choice tasks. This is surprising as the two dominant modes in terms of percentage share in the modal split of the Port of Ghent as reported for the 2016 modal split for outgoing transport flows leaving the port are the IWW mode (55% share), but also the road mode (34% share) (Port of Ghent, 2017). In addition, a 67% share of the road mode being the main mode in the outgoing typical transports can be noted in this sample (yet not for the ingoing typical transports). Therefore, it would have been expected that the respondents would reveal a tendency to choose (ceteris paribus) the road alternative.

With regards to the coefficient estimates of the cost, time and CO_2 emissions attributes, it can be noted that the MNL model underestimated these compared to the MMNL model. The MMNL reported estimate for the time coefficient is almost 1.5 times higher than the MNL estimate, the cost coefficient 1.18 times higher and the environmental attribute 1.27 times. In addition, it can be concluded from the MMNL model that there is significant random taste heterogeneity present across the respondents with regards to the cost

attribute. This is as expected as the companies differ greatly from one and another in terms of main product shipped, inventory management, production process etc. It can be concluded from the estimation results that the respondents are most likely to choose away from costly alternatives, and to a smaller degree likely to choose away from fast and polluting alternatives. Unfortunately, the data sample did not allow to test for heterogeneity according to market sector or product type to further investigate taste variation.

Whereas the loss and damage coefficient estimates were not found significant across all the different model structures, the reliability attribute plays an important role. It consistently yields a significant and highly positive estimated value, indicating a strong preference of the decision-makers for more reliable alternatives.

With regards to the attitudinal effects, the model structures to compare are the ICLV using one latent variable to account for underlying environmental attitudes and the ICLV using two latent variables which specifies the attitudes as a function of the individual or of the company. The ICLV 1LV model reports significant effects of the attitudes with the cost and time attribute, as well as with the inland waterways modes, indicating that more environmentally orientated individuals in terms of attitudes are less sensitive to time and more sensitive to cost, while also being more likely to choose alternatives with the inland waterways as main mode. However, when comparing with the effects found in the model using two distinct latent variables the effect of both LV I and LV C with the inland waterways mode remains only significant based on the standard t-ratio, but not on the robust t-ratio. In addition, the ICLV 2LV model gives a significant effect of the latent variable with regards to individual environmental attitudes (LV I) and the short sea shipping mode. On the 10% significance level (robust t-ratio), it is found that more environmentally friendly individuals tend to be more likely to choose the SSS alternatives. The dual LV approach was applied to test for the behavioural assumption that the attitudinal effect on the choice made on behalf of the company could be separated in individual attitudes and how the environmental outlook of the company is perceived by the employee. While the ICLV 2LV model shows an additional effect with the SSS mode, it is found to perform less well compared to the ICLV 1LV model based on significant effects (robust t-ratio as criteria). Therefore, the ICLV 1LV model serves as the base model for the mixed model with quantified qualitative themes.

Whereas looking at the interpretation of the estimation results and their significance serves as an initial comparison, it is important to understand the differences between the models and compare them based on formal statistical criteria to find the most fitting model. This is described in the following section on goodness of fit criteria.

5.2.5.1. Goodness of fit

Different choice models can be compared to each other by using goodness of fit measures. One of the conventionally widely applied goodness of fit measures of discrete choice models, is the McFadden pseudo rho-squared measure. It compares the estimated model at convergence with a null model (all parameters are set to zero) (reference to Train, 2009):

$$\rho = 1 - \frac{LL(\beta)}{LL(0)}$$

It is argued that with regards to discrete choice models a value between 0.2 and 0.4 is considered a good model fit (McFadden, 1979). However, in general it is found that the model fit improves when adding more parameters to the model. Therefore, the adjusted pseudo rho-squared measure is advised to use as it penalises for the number of parameters. A decrease implies that the model is being overfitted:

$$\overline{\rho^2} = 1 - \frac{LL(\beta) - p}{LL(0)}$$

In addition, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) are often used to compare between different model structures. The AIC is said to penalise the LL to account for model complexity. The BIC implies that models containing more parameters are penalised. The AIC and BIC criteria are:

$$AIC = -2(LL(\beta) - p)$$
$$BIC = -LL(\beta) + 0.5\,.\,p\,.\,LN(N)$$

With p = number of parameters
N = sample size
$LL(\beta)$= log likelihood at convergence

The model with the lowest AIC and BIC tends to perform best in terms of model structure.

Lastly, the Likelihood ratio test is often used to compare models, in which the LR test value is defined by -2(LL(restricted_model)-LL(unrestricted_model)) and distributed chi-squared with the degrees of freedom specified by the number of parameters of the restricted model minus the number of parameters of the unrestricted model (Train, 2009).

Table 20 includes the selected criteria across the models.

Table 20: comparison of models (goodness-of-fit)

	MNL	**MMNL**	**ICLV 1LV**	**ICLV 2LV**
LL(0)	-744.32	-744.32	-896618.9	-1044913
LL(final)			-518.60	-619.29
LL(choice)	-460.53	-446.77	-437.99	**-435.41**
parameters	12	15	27	44
AIC	945.06	**923.87**	1091.21	1326.59
BIC	997.82	**989.5**	1209.92	1520.05
rho-sq (0)	0.38	0.40	n/a	n/a
adj rho-sq (0)	0.37	0.38	n/a	n/a
LR test		MNL (base)-MMNL: 4.6e-06(***)		ICLV 1LV (base)-ICLV 2LV: 1

When comparing the log likelihoods at convergence, the MMNL outperforms the MNL. This is confirmed by a significant log likelihood ratio test, in which the MNL is used as the base model. Furthermore, both the AIC and BIC are found to perform better for the MMNL model compared to the MNL model (smaller). The superiority of the MMNL compared to the MNL is also reflected in the adjusted rho-squared measure.

Comparing the ICLV model structures with those of MNL and MMNL, the loglikelihoods of the choice models seem to perform better in the ICLVs, but as the number of parameters used in the ICLV frameworks is much higher, the AIC and BIC tend to be much higher (and thus statistically speaking perform worse). In addition, it can be noted based on the likelihood ratio test that the model structure including two latent variables is not a significant improvement compared to the model structure including one latent variable to account for environmental attitudes.

However, a small reflection is in place. While goodness-of-fit measures provide a good toolkit for researchers to assess models and select models, caution is needed to not solely rely on these measures. Estimation results and their significance, as well as their interpretation-value need to be taken into account. In addition, it seems unfair or even unhandy to compare the ICLV models with the MMNL and especially MNL model based on the given criteria in Table 20. As the ICLV's contain more parameters and are more complex in terms of model structure, they will be more heavily penalised by the BIC and AIC. Nevertheless, taking into account the goodness-of-fit measures, model estimates and interpretation value of the different models, it becomes clear that the MMNL and ICLV 1 LV model give us a superior understanding of the different impacts on freight mode choice, either by insights from the coefficients of the attributes or by the impact of environmental attitudes revealing interesting interaction effects.

The next section will shortly compare the policy measures derived from the MNL estimation results and MMNL estimation results respectively.

5.2.5.2. comparison policy measures: MNL - MMNL

This section will compare the policy-relevant willingness-to-pay measures derived from the MNL and MMNL results. Table 21 provides a comparison.

Based upon Table 21, it becomes visible that the MNL underestimated the measures as all the WTP's derived from the MMNL model estimates tend to be higher. This is most pronounced for the value of time (+62.3%) and can be explained by the coefficients derived from the MMNL for cost and time (more negative) compared to those derived from the MNL model.

It is also very pronounced with regards to the willingness-to-pay for less loss and damage to the typical transport (+61.7%), although the loss and damage estimate coefficients were not found significant. A 37.5% increase in the willingness-to-pay for a reduction in the CO_2 emissions per typical transport is also notable for the MMNL outcome compared to the MNL outcome. Lastly, the willingness-to-pay for a more reliable service of the typical transport

expressed in terms of percentage arriving on time increased by 15% for the MMNL model compared to the MNL model.

Table 21: overview WTPs MNL & MMNL (in EUR, 2017)

WTPs (EUR)	MNL	MMNL
VOT (day)	3.94585	6.4032
VOT (hour)	0.16441	0.2668
VOR (1% increase)	3.4935	4.0178
VO_ENV (1 tonne CO_2 emissions)	1.34035	1.8431
VO_LD (1% decrease)	41.5063	67.1342

The question now becomes how these derived results compare to the results reported in the literature. For each of the measures, a European focus is taken to do so.

The VOTs expressed per shipment based upon both the MNL and MMNL model results are significantly lower than the VOT reported in the Dutch value of time study of de Jong et al. (2014). It needs to be noted that the authors report a VOT of 38 EUR for the overall road mode (non-container) which consists both of a transport component and cargo component. However, as de Jong et al. (2014) argue, the cargo component comes down to 20% on average in the Netherlands. Therefore, the measure to compare to becomes 7.4 EUR per hour per typical transport, which is considerately larger compared to the found 0.16 (MNL) and 0.18 (MMNL) EUR per hour per typical transport in this study. In addition, the recent study of Jensen et al. (2018) provides new VOT (cargo) measures of a transport chain choice model in the setting of the European Transtools 3 project. In addition, they also include an overview table of reported VOT measures relating to the cargo component in the freight literature. However, all cargo components VOTs are expressed in euro per ton per hour.

As the sample in this application showed a wide range in terms of tonnages per typical shipment (including a few very large shipments), it was decided to use the median value instead of (the conventionally more used) mean value to derive VOTs per ton per hour. The VOT per ton per hour in this study results in 0.00033 EUR/t/h derived from the MNL model and 0.00053 EUR/t/h derived on the MMNL model. These are considerably lower than the

result found in Jensen et al. (2018), which reports on a VOT (EUR/t/h) between 0.12-0.18 for land-based modes transporting dry bulk and 0.06-0.11 for water-based modes transporting dry bulk. The review of the literature yields values with a lower bound of 0.01 EUR/t/h. It is opted to use the reference values of Jensen et al. (2018) for dry bulk, as the sample in this application is mostly represented by dry bulk. To be consistent with the mentioned study, separate models per land or water-based modes were estimated to derive VOT measures. However, while the water-based models (MNL and MMNL) yielded acceptable results (stable error terms and t-ratio's), the land-based models resulted with high standard errors, which indicates the instability of the models. It is argued that there are simply not enough choice observations with land-based modes as reference modes for the typical shipment to estimate stable models. Therefore, only the cargo component related VOT of the water-modes models is given for comparison. These are 0.0006 for the MNL model and 0.00062 for the MMNL model, which is still lower than the 0.06 – 0.11 reported for dry bulk in Jensen et al. (2018). The lower VOTs found in this study could be linked to the qualitative findings (as reported in the second results chapter), in which transport time for a group of interviewees was perceived as an irrelevant factor in their decision-making in practise with regards to mode choice as it was argued that it came down to planning. However, different nuances were made with regards to the qualitative theme of transport time.

The VOR for a typical shipment is expressed in a 1% increase in the percentage arriving on time. Fries et al. (2010) report on a measure of 19.8 CHF per shipment for a one percentage-point increase for on-time reliability. The Belgian study of Beuthe and Bouffioux (2008) provides Belgian willingness-to-pay estimates, however, all reported measures are in units per ton-kilometres and therefore difficult to compare with. Their estimate for a one percentage point-increase in reliability is 0.0112 per ton-km. However, they list the median distance (global: 320 km) as well as median shipment size (global: 20 ton). Multiplying these leads to a measure to compare with of: 71.68. However, the median shipment size in tonnages and mean distance in this application are much higher (500 ton and 600 km) as the sample constitutes mainly of bulk and breakbulk. Multiplying these with the estimate reported by Beuthe and Bouffioux (2008) gives an estimate to compare with of 3360. However, multiplying the VOR value with the median tonnage and average distance results

in a much higher value, therefore it might be concluded that the willingness-to-pay for a one percent increase in reliability of a typical transport in this study is found higher.

The willingness-to-pay for a one percent decrease in loss and damage is expressed in terms of annual probability and is reported 61.6 CHF (MNL) in the study of Masiero and Hensher (2012), which is currently converted to around 54 EUR. However, as the attribute was not expressed in an annual format, but still is interpretable on a one percent decrease of loss and damage we can conclude that the measure found in this application falls in the same order of magnitude, with the MNL derived result being slightly lower and the MMNL derived result higher. The Italian freight transport service choice study of Rotaris et al. (2012) reports significant coefficients for the loss and damage attribute under different transformations applied upon the cost, loss and damage, travel time and punctuality attributes. However, the WTP with regards to loss and damage is only reported for the base (linear) model and Piecewise specification. Therefore, the found measure in this study will be compared to the value of the linear model of 97 EUR (Rotaris et al., 2012). Both the MNL as well as MMNL derived WTP for a one percent decrease in loss and damage per typical shipment in this study tend to be lower. However, it needs to be said that these comparisons cannot be based on a significant result as the loss and damage parameter coefficients were not found to be significant, not in the MNL nor in the MMNL model in this application.

With regards to the willingness-to-pay measure for a reduction in CO_2 emissions per typical transport, the measure reported in the study of Fries et al. (2010) serves as the benchmark. However, it needs to be noted that it is not straightforward to compare the measures found to this benchmark for two main reasons. Firstly, Fries et al. (2010) specified the CO_2 emissions attributes in terms of absolute percentage changes with regards to the current and the study here used the same intervals but upon a simplified European average (see Survey Chapter, section 4.2.1.). Secondly, the value reported is based upon a MMNL model using Normal distributions for the random parameters, whereas the value reported in this study uses (negative) Lognormal distributions. It has been noted already that the type of distribution assumed can have significant effects on the result outputs and derived WTPs (Axhausen et al., 2005; Hess et al., 2005). In addition, Fries et al. (2010) report the measure in terms of a one-percentage-point emissions reduction in the Swiss currency (CHF): CHF1.27

per shipment (≈1,11 EUR). With these considerations in mind, a slightly higher willingness-to-pay is noted for a reduction of one ton in CO_2 emissions per typical transport. However, this depends on the mean reference value for the CO_2 emissions in the study of Fries et al. (2010), which is not reported.

5.2.6. Reflection

The sections above presented the model results with regards to the research questions concerning impact on mode choice. The approach to address these was by quantitative choice modelling techniques, namely the MNL, MMNL and ICLV models. Whereas the MNL model assumed homogeneous taste preferences across the decision-makers, the MMNL added random taste heterogeneity for the transport cost (tariff), transport time and environmental attribute. In addition, the ICLV framework expanded the choice model with the inclusion of environmental attitudes by using latent variables. The model results showed interesting and significant effects of on the one hand, the attributes and one the other hand, environmental attitudes. In terms of attributes, reliability, transport cost, CO_2 emissions and transport time were found significant. In terms of attitudes, interesting interaction effects were noted with the inland waterway and short sea shipping modes. The main surprise was that the rail mode was not treated any significantly different from the road mode, which was not as expected based on EU CO_2 emission data per ton-km per mode. In addition, the choice model estimation results were used to derive willingness-to-pay measures with regards to the different attributes. These are argued to be relevant to serve as input for policy decision-making processes.

However, some estimation results were not as expected or not found significant, for example with regards to the loss and damage attribute. The different model results will be examined in relation to the derived qualitative findings in the second result chapter, aiming to provide more context to the estimation result as well as gaining insight on the underlying perceived contextual factors by the interviewees with regards to their mode choices in practice.

The discussion chapter will elaborate further on the findings highlighted in this chapter.

5.3. Results Chapter Two: Integrating QL and QN in relation to mode choice

5.3.1. introduction

Whereas the focus of the first results chapter was on assessing the impact of transport time, transport cost (tariff), loss and damage, reliability and $C0_2$ emissions upon logistic managers' preferences with regards to mode choice by applying the quantitative technique of choice modelling, the focus of the second results chapter shifts towards including qualitatively derived insights on mode choice and addressing integration between both the qualitative and quantitative analysis.

The chapter is structured as follows. Firstly, the general structure of the thematic analysis output will be briefly highlighted in order to relate the qualitative findings to on the one hand, the choice model estimation results and on the other hand, relating them to the topic of mode choice in practice (section 5.3.2). The thematic analysis resulted in 64 themes of which 61 were grouped in eleven clusters. These themes reflect what the respondents specifically brought forward as perceived factors of interest when elaborating upon their mode choices made in practice during the qualitative interview. The perceived factors that were mentioned most across respondents (with a minimum requirement of five respondents or more) will be highlighted. Put differently, the first part addresses the research questions on gaining insights on the contextual setting in which mode choices are made, both the general perceived context as well as the specific perceived business context (RQ1.D and RQ1.E).

Secondly, the focus will shift towards gaining insights on the participants' experiences with regards to the stated preferences survey. This is based upon the reflections made by the respondents during the qualitative interview when asked on the stated preferences survey after completing all the choice tasks (section 5.3.3). This section is structured according to reflections made by the respondents that relate: to the choice tasks (5.3.3.1), to specific attributes (5.3.3.2) and the perceived differences between the within-mode and between-mode choice tasks in terms of difficulty level to complete (5.3.3.3). In other words, the second part relates to the research questions formulated with regards to the perceived *"realism"* of

the stated preferences survey as compared to the logistic managers' decision-making in practice (RQ2.1 & RQ2.2).

Thirdly, a brief reflection and argument is given on why it is relevant to take the respondent's perspective for gaining an in-depth understanding of freight mode choice (section 5.3.4).

The discussion on the quantitative model efforts that were made to explore the incorporation of a subset of the derived qualitative themes into an extended choice model framework forms the fourth part of this chapter (section 5.3.5). An integrated choice and latent variable (ICLV) model framework is argued to be most appropriate, as the themes are considered latent variables and the binary variables which indicate the presence of such themes with the respondents are considered indicators. Unfortunately, due to data sample size limitations no further modelling efforts were undertaken at this moment. It is argued that additional data will be necessarily to fulfil such requirement.

A side note needs to be made with regards to the use of the respondents' quotes, which will occur throughout this chapter to illustrate or support insights. To safeguard the anonymity of the companies, some particularities which could identify the company will be hidden by using "[XXX]" marking. These can include [product name], [company name] etc. This is in line with the Ethics Review and participants consent form as approved by the University of Leeds (reference number: AREA 14-110).

5.3.2. Qualitative findings in relation to mode choice

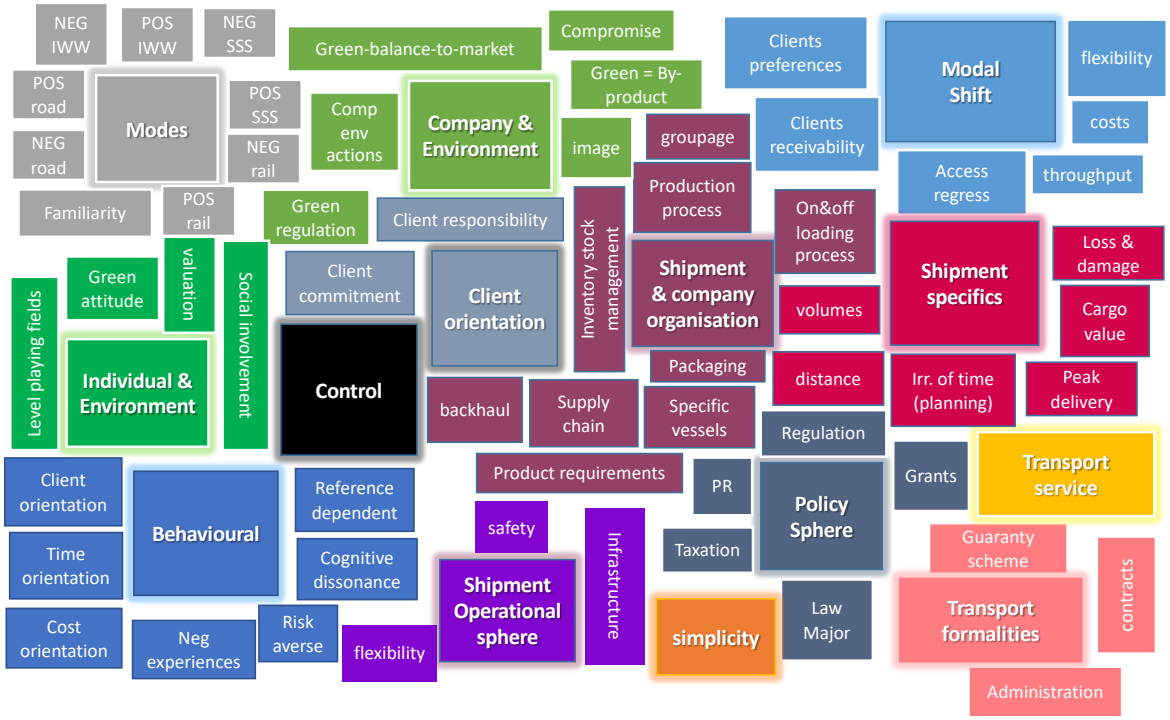
5.3.2.1. Qualitative Thematic Analysis: general output

The thematic analysis of the transcribed interview data resulted in an extensive node coding structure using the Nvivo software, which lead to the identification of 63 themes. These themes could be clustered in 11 groups, with three themes remaining single as they relate to all and form an additional layer. The coding of nodes and derivation of themes took up to four months due to the iterative nature of the node coding approach, which was discussed in the methodology chapter.

The Nvivo software provides auto-tools to derive queries upon the node coded text and node structure. These served as preliminary starting points to assess the presence of potential clusters and patterns within the node structure. These preliminary queries provided a useful start to gain more insight into the node structure. Two output examples of such query runs are given in Appendix (figure B and C), in which the nodes were auto-clustered by either coding similarity or word similarity (minimum of 5 characters). While the Nvivo auto-clusters showed the potential presence of multiple clusters, it was opted to derive the thematic clusters manually.

The outcome of the manual thematic cluster analysis is graphically displayed in Figure 14. Themes grouped together in the same colour form a cluster. The larger boxes with shading indicate the main grouped topic in the cluster, these are: company and environment, modal shift, shipment operational sphere, shipment and company organisation, policy sphere, transport formalities, shipment specifics, individual and environment, modes, client orientation and behavioural. Control, transport service and simplicity are not added to a particular cluster as they are interrelated with most and form dominant themes throughout individual interviews and across interviews.

Figure 14: thematic analysis output (graphically)



These themes and clusters derived upon the initial node coding structure are used to derive insights addressing the particular research questions with regards to the contextual setting of mode choice and SP *"realism"*. However, only the relevant found themes based upon mode choice with regards to these questions will be considered. Their underlying meaning will be elaborated upon in the corresponding sections. In addition, only themes that resonate with a minimum of five or more respondents will be highlighted. This implies that the theme needs to be present in at least 25% of the interviewee sample. This is done to reduce the number of themes to a more approachable set as well as safeguarding resonance of the theme across the sample. The following section will briefly put forwards the relevant qualitative findings parallel to the choice model estimation results from results chapter one (5.1).

5.3.2.2 Qualitative findings relating to the choice model estimation results

This section will briefly match relevant qualitative insights with choice modelling results, namely the model attributes coefficients results on the impact of: transport time, transport cost (tariff), loss and damage, reliability and CO_2 emissions.

Throughout the qualitative interviews, a cost-orientation is dominantly present in the reasoning of all interviewees, both when answering questions on their mode choice in practice as well as on the topic of modal shift. Therefore, it is not surprising to see this reflected in the choice model estimation results in the form of a significant cost attribute coefficient of negative sign, which indicates that individuals are sensitive to higher costs (impacting their preferences and thus likelihood of choosing such alternatives). In addition, the MMNL results indicate the presence of random taste heterogeneity across respondents for the cost attribute. However, the qualitative findings do not go in-depth into the differences across interviewees with regards to their perceived cost-importance.

The time attribute coefficient was found significant and was expressed in days from door-to-door of a typical shipment. When comparing this result to the qualitative findings with regards to time and the more often mentioned peak-delivery time, a more diverse range across interviewees is visible. A group of interviewees perceived transport time to be irrelevant when making freight transport mode choices, in which they stated that it *"all comes down to good planning"* as the actual duration of the shipment does not matter. In contrast, others stressed the importance of time that the shipment is underway. Therefore, starting from the qualitative findings it was surprising not the find significant random taste heterogeneity in the transport time coefficient estimates.

Similar to the transport time attribute, a varying result is visible across interviewees when elaborating upon environmental factors such as emissions (also including the broader spectrum of GHG emissions) in relation to mode choices they make in practise. This ranges from: either stressing its complete irrelevance, or it merely being a by-product that comes with the use of certain modes, to taking a more neutral stance. The CO_2 emissions coefficient is consistently found rather small across the different choice models, which coincides with the respondents' perception that it isn't really a dominant factor when making transport mode choices (currently). In addition, based on the qualitative findings, significant random taste heterogeneity across the respondents with regards to the environmental attribute coefficients would have been expected.

The reliability attribute coefficients are found to be significant and of positive signs across the choice models, indicating that the logistic managers' preferences are positively impacted by a more reliable alternative and therefor have a higher likelihood of choosing such alternative. This is also echoed in the qualitative data, in which reliability is strongly present throughout the reflections on mode choice and also in relation to the topic of a modal shift. It is expressed as an important factor when deciding on the mode choice in practice.

Interestingly, the loss and damage attribute coefficients were not found significant across the choice model results. Compared to the emphasis made by the participants on reliability in the qualitative interviews, the loss and damage argument came less to the surface in their reflections upon mode choice. In addition, it did not surface at all in the discussions upon the modal shift topic.

From the ASCs related to the labelled choice tasks, no significant estimates were found. Indicating that the respondents did not have the tendency to stick with either the road, IWW or rail labelled alternatives (ceteris paribus). However, based on the findings from the qualitative data, it would be expected to see a tendency to choose away from the rail-mode labelled alternatives in the model results. The majority of the respondents perceived the rail mode negatively. In particular, a group of respondents were observed to perceive it as difficult as they stated to have negative experiences with it in the past. In addition, the rail mode is found to be perceived negatively in the thematic analysis on the topic of modal shift (results chapter three).

These qualitative insights will resurface in section 5.3.3, which puts the qualitative insights in light of the perceived *"realism"* of the choice tasks in comparison with the respondent's decision-making in practice on mode choice.

The next section continues to elaborate on the relevant qualitative themes found in relation to the topic of mode choice.

5.3.2.3. Adding context to mode choice

This section deals with the contextual setting -as described by the participants- relating to their mode choice in practice. This contextual setting needs to be understood as factors that were perceived relevant or were brought up by participants when reflecting upon their mode choices. Research question RQ1.D was intentionally expressed in terms of the broad word "context", in the sense that both reflections made upon market conditions as well as the perceived regulatory framework could be contained in its meaning. However, as the specific business related context (transport organisation, product flows, production process, inventory stock etc.) is also found relevant to mode choice this was specified in research question RQ1.E. Both are addressed together in this section.

The dominant thematic clusters found across respondents to describe the context and specific business context in relation to their mode choices are: control, shipment and company organisation, shipment specifics, shipment operational sphere, transport formalities and policy sphere. Looking at individual themes, the top ten occurring themes in terms of percentage-share across the 20 participants are given in Table 22. Put differently, the table reflects the percentage share in the sample of participants that elaborated upon the theme.

Table 22: %share of top 10 themes related to mode choice across the sample

Theme name	%share in the sample
CONTROL	95%
INV_STOCK_MANAGEMENT	80%
VOLUMES	70%
COST_ORIENT	60%
CONTRACTS	55%
ON_OFF_LOADING_PROCESS	50%
CLIENT_ORIENT	50%
PRODUCTION_PROCESS	45%
PEAK_DELIVERY	45%
POLICY_SPHERE(REG)	45%

Each relevant cluster setting the contextual element to mode choice will be highlighted in the following. However, the thematic clusters should not be seen as unrelated. Often themes within the cluster cross over to other themes belonging to a different cluster and such

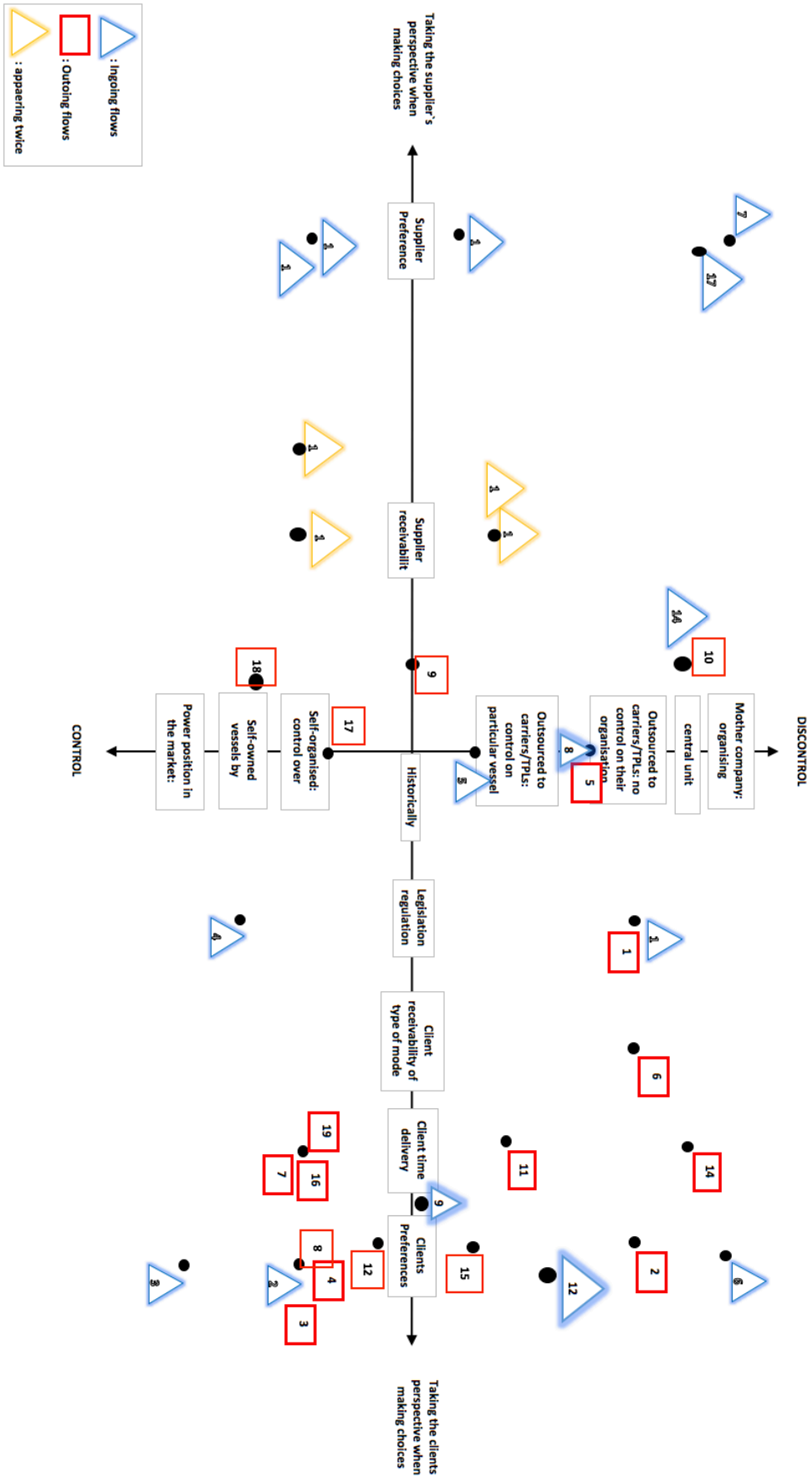
connections will be highlighted. Firstly, the non-clustered, single theme of control will be discussed, followed by the shipment and company organisation cluster. Next the shipment specifics cluster will be highlighted, followed by the shipment operational sphere cluster which is closely related. The individual theme of contracts within the transport formalities cluster will follow next. Lastly, the more sensitive topic of the Law Major theme within the policy sphere cluster will be approached with caution. The word 'sensitive' is used as the Law Major has both strong proponents as well as opponents in the public debate.

Control

It can be derived from Table 22 that the dominant theme which is found across the different respondents relating to the contextual setting of mode choice is **CONTROL**. As mentioned, this theme was not added to a specific thematic cluster as it relates to all and acts as an additional layer. The control theme holds the reflections made by the respondents with regards to their perceived power position with respect to the transport mode choice, in which five differences can be distinguished relating to specific sub-groups of participants. Either respondents were observed to have a strong client-orientated focus in their reasoning, in which they stressed the clients' needs in terms of ability to receive of the modes (both in terms of accessibility and volumes) or legislative requirements (in the context of safety), their desired delivery times or clients' preferences for certain modes. A supplier-orientated focus was taken when elaborating upon the degree of control they have upon the mode choice, in which their own ability to receive modes or supplier's preferences were emphasised. In addition, in some cases the power relation in which a central unit or larger mother company steered the mode choices was stressed. Lastly, respondents ranged from being firmly in control on the mode choice by owning their own transport vessels to having less control as the transport functions are outsourced. Interestingly, many of those different perspectives taken across respondents were noticeable, but also within respondents when elaborating on either ingoing transport flows or outgoing transport flows. To get an idea of potential clusters of individuals or according to their transport flow direction, these differences were graphically mapped out in Figure 15. It graphically shows these differences across respondents as well as within respondents according to two main axes. The vertical axis reflects the perceived degree of control the respondents have in steering the mode choice, including the use of labels that participants applied. The horizontal axis represents on the one side the client-orientated

perspective which was taken and on the other side the supplier-orientated perspective taken. However, some combinations of respondent and transport flow direction could not be mapped as they did not reply equally open to every question. In addition, two participants in terms of their ingoing-flows were mapped twice as they apply on both sides of the control axis. These are indicated with a yellow colour.

Figure 15: respondents per flow mapped out on control and orientation axes



Based upon Figure 15, it can be seen that the majority of respondents when reflecting upon their outgoing transport flows take a client-perspective. This is positioned towards the right side of the graph. It does not come as a surprising insight, since it makes sense from a commercial point of view. In addition, a group can be observed to organise and plan their own transportation for outgoing flows, but not owning the transport vessels. These make use of specific forwarders with whom they negotiate contracts. Another group can be identified for the outgoing flows that outsource the organisation and planning of the transport, however, with the nuance of having control over the mode choice and not having control over the mode choice as a company.

Participants elaborating on their ingoing flows are more spread out across the graph, indicating a wider range of perspectives they take when elaborating on mode choice and the perceived degree of control for their ingoing transport flows to the company. This in sharp contrast to the SP survey, where the choice tasks are set up with the participant in a full control setting to decide on the choice task alternatives.

Shipment and company organisation

The first cluster of themes which produced interesting insights with regards to the corporate context in which mode choices are made in practice is the 'shipment and company organisation' cluster. Three of the themes that belong to this cluster have a large percentage-share across the sample (inventory stock management (80%), on -and offloading process (45%) and production process (50%)). The other themes belonging to this thematic cluster are supply chain, product requirement, specific vessels, packaging, backhaul and groupage. Only, the themes which resonated in at least five or more respondents will be highlighted.

Firstly, sixteen interviewees stressed that their mode choices in practice are related to the inventory stock organisation of the company, as particular modes (such as rail, short sea and inland waterways vessels) are perceived to affect the stocks differently. However, it can be noted that in the majority of respondents the inventory stock factor was related to their mode choice operation with regards to waterborne vessels (inland and short sea). One specific respondent even specified to regard the goods in such vessels as floating stock as part of his planning process:

"Yes, in some cases waterborne vessels can also be used like stock. In our [name]report we count ships as a sort of floating tank." (Interviewee 4)

However, the stock implications of using waterborne vessels as mode were perceived as both a negative and a positive factor by different respondents.

"If you think of waterways you have additional complexity in the sense that inventory stock fluctuations are much larger, which means extra planning and becomes thus a disadvantage for the inland waterways." (Interviewee 5)

"The combination of stock that is here and stock that is on the ship. Stock is working capital which you need to finance and that costs money." (Interviewee 3)

"The advantage of the inland waterway mode is that you work with a larger transport lot, so that automatically you have larger safety-stocks and it is cheap." (Interviewee 1)

Secondly, the on- and offloading theme shows that a large group of respondents (10) take their own experience with regards to on -and offloading different modes into account when reflecting on their mode choice in practice. Most respondents simply described the on -and offloading process for their current flows. In contrast, one specific respondent perceived the on- and offloading demands to work as a barrier for using the waterway mode:

"I'm really a fan of water transport, but water transport is so problematic for us, because of the nature of our product, the onloading is always the issue. Dust, grippers, cranes, etc. Also the loading births are often problematic." (Interviewee 5)

Thirdly, nine interviewees were observed to reflect upon their production process in relation to mode choice. The main reflection made is on the relation to the continuity of the production process. Multiple times, it is further linked to the perception of reliability of the transport service, which is perceived as important to safeguard the continuity of the production process. While not directly stated by the participants on record, it can be assumed that the costs of stopping and starting industrial processing machinery again is financially more burdensome or less efficient than having a continuous process running at base level.

"What is important in this is the production, the continuity, to keep that going" (Interviewee 6)

In addition, three of those interviewees linked the production process factor to their inventory stock capacity when addressing mode choice.

> *"Anyway being on time [the transport mode], you need to know how the factory is organised. We do a lot of "production on order". Actually it's almost similar to "just in time". We have a small stock, [number] pallet places, which is quite small. It is the intention that constantly what is produced today is -in a matter of speaking- within three days out of our stock, or even the same day" (Interviewee 17)*

Also, the production process of the client was put forward by two interviewees as a determining factor for having a reliable transport service. In this way, the theme of production process was not only found to relate to the inventory stock theme within the cluster, but also to the single theme of control by taking a client-orientated perspective.

> *"We work towards industrial clients which are really dependent on our [product name] as input material. So we cannot cause problems with our clients in their production lines. The reliability of delivery and no damage is very important." (interviewee 19)*

Fourthly, seven interviewees stated that their mode choices made in practice simply depend of the specific vessels required to transport their products. Either a specific ship, cooling container, cooled truck or special regulated transport in terms of safety.

> *"We also have incoming goods with the rail mode, namely [product name]. It is only allowed to be transported using rail. That's the [name]regulation with regards to dangerous goods across the rail. Logistically, that is a difficult knot." (Interviewee 7)*

Fifthly, the specific vessels theme is closely linked to the product requirements theme, which was stressed by six of the seven respondents that also elaborated on the specific vessel needs. Again, safety regulation was stressed, as well as product requirements in terms of temperature and shipment.

> *"Most of our incoming products are liquid and that have to be silo transports. That is sodium oxide, aluminium, …" (Interviewee 8)*

Lastly, a supply chain perspective was observed in the reasoning of five respondents, putting the mode choice in the setting of the entire supply chain. Interestingly, two respondents clearly linked the mode choice in their supply chains with the perceived importance of the reliability attribute.

"It is as a chain that hangs together, with a supply chain that connects. Everyone needs to be reliable. If there is something in the transport mode which isn't reliable, and if you're at the end of the chain with nobody depending on you, or you might have a large margin, then. But in our situation of a production-unit, well, then reliability is crucial. Your machinery, energy supply, your suppliers, you name it, that is almost more important than your price." (Interviewee 2).

Shipment specifics

Three individual themes within the shipment specifics cluster will be highlighted as these were present with a minimum of five or more respondents in the sample in relation to mode choice in practice. These are: volumes, peak delivery and loss and damage.

Volumes was brought up by 14 of the respondents in relation to mode choice. The underlying meaning as perceived by the participants of the theme is straightforward: larger volumes tend to be moved by using larger transport vessels such as the waterborne and rail modes.

"Having the right ships with the right tonnages. One works with larger ships and larger tonnages and it's hard for me to get smaller vessels and we need both! We do both transport of 7000 ton, but also [name of good] transport of 1000 ton, so smaller waterborne vessels need to be available. […] Because we work with these tonnages, it wouldn't make sense to start working with trucks." (Interviewee 2)

The theme of volumes will resurface in the third results chapter on modal shift as it was also brought up by the respondents during the questions on modal shift.

Nine respondents put peak-delivery forward as a factor influencing their mode choices in practice, especially in relation to their outgoing transport flows towards their clients. This again connects to the control theme, in which a client-orientated perspective is taken. However, one respondent also mentioned peak-delivery in the context to ingoing flows.

"Especially the time pressure is an important criterion for the choice of transport. […]. Just-in-time delivery is a crucial factor in the delivery towards the clients" (Interviewee 9)

"When you want a short supply-chain with just-in-time delivery as you want to avoid unnecessary stocks and don't want to invest in storage, so making sure you have the

product in the right moment at the right place. It's almost a cliché, but it comes down to that." (Interviewee 4)

Five respondents were observed to elaborate on the factor of loss and damage while reflecting upon their mode choices in practice. Interestingly, this was mostly done with a focus on the clients of the company (again linked to the control theme).

"If you choose for a transport mode where you have less risk on damage, it is important also for the company, to have as few damage-claims as possible." (Interviewee 2)

"I think we look first and foremost if the client received his goods in the state that he wants with as less as damage. Then we look at the accuracy of the delivery time." (Interviewee 16).

Shipment operational sphere

Two themes in the shipment operational sphere cluster will be mentioned in relation to reflecting upon mode choice by the respondents. Firstly, the safety theme and secondly, the infrastructure theme.

The element of safety was addressed by five respondents and already surfaced when respondents related mode choice to the themes of specific vessel needs and product requirements. In addition, safety was observed to be put in the context of either regulatory compliance or in the context of the safety norms emphasised by the company itself.

"[Company name] puts emphasis on safety, what automatically is linked to environment. Legislation compliance, if those are not met, we will not even consider the mode, it's that simple." (Interviewee 1)

"We work for a new company and safety is a top priority. Our boatmen need to sign all our safety document, so they know how everything works here. We also work with one and the same unloading firm, so we always know which people come here. They know our safety rules as well." (Interviewee 2)

Port infrastructure as well as company-owned infrastructure were mentioned by five respondents. It was perceived to be a factor to be taken into account when deciding on mode choice, although, not elaborated upon in great detail. In addition, it needs to be mentioned that a full multi-modal range is present in the Port of Ghent region. This includes connectivity

via water, rail, road and pipes. Not all companies are located directly at a quay, but there are officially recognised stevedores present which can receive, on -and offload and process the cargo. However, this is a sensitive topic which will surface in the discussed policy sphere cluster below.

> *"The infrastructure [waterborne] is there to do it." (Interviewee 15)*

The infrastructure theme was also identified in the thematic analysis in relation to the topic of a modal shift, which will be illustrated in the third results chapter.

Transport formalities cluster

The most present theme across the respondents in the 'transport formalities' cluster is the 'contracts' theme. Contracts were brought up by eleven of the respondents in the sample as an additional layer when reflecting upon their mode choice in practise. Either from a perspective in which contracts are negotiated with carriers or either from a perspective were contracts are negotiated with their clients. Most contracts were mentioned in a short-term duration ranging from under one year to maximum up to three years. The argument given for such time lengths is one of market evolution.

> *"I think that that in the past there were even more contracts. We have a lot of clients that just come and stay, but there are also clients that disappear after two to three years. It's a matter of the market." (Interviewee 9)*

However, one respondent stood out by making a distinction for a particular contract which is in the context of large volumes and specific requirements with regards to the storage within sea vessels.

> *"For the outgoing flows you really only have one long term contract, that is for the ships that we use for our delivery of marine [product name] to the ports of Antwerp and Rotterdam. That are very big investments for our partners and therefore the contracts are of a duration of ten years, which is very exceptional for [company name], because normally it is maximum three years. But you need to understand that such ships are specially customized for us ... [participant elaborates how]." (Interviewee 17).*

Policy sphere cluster

The policy sphere cluster is mostly found in relation to the topic on a modal shift, which will be discussed in the third results chapter. However, government regulation did get stressed by nine out of the 20 respondents in the specific context of the Law Major, which only applies within the official port geographical boundary. The Law Major dates back to the 1970s with its most recent alterations in 2016. It puts strict regulations on the manner in which dock work is performed in the ports in Belgium (handling and on -and offloading cargo from waterborne vessels at port quays). The law regulates the number of dockworkers as well as limits this activity to solely officially recognised dockworkers. This law is a sensitive topic, as it has not been without critique as well as having strong advocates, resulting in a strong public debate. The aim of this analysis is not to make a normative judgement about this regulation, but it became clear from the qualitative analysis that this theme did play a role for almost half of the participants when reflecting upon their mode choices in practice.

The general perception with regards to the Law Major with those respondents is rather negatively orientated. Meaning that in their perception the Law Major results in higher costs and acts as a barrier to using the waterborne modes (especially short sea).

> *"The dockwork [Law Major] also increases the costs enormously and also decreases the flexibility." (Interviewee 5)*

> *"The high costs we have with our transports is with sea and inland waterways, those are the costs related to dock workers. Those are too high and not adapted to the current way of working in society. So be it, that's a different matter. It needs to change and hopefully it will be required by Europe. So there are different factors why you would chose or rather for a particular mode. My preference from all the modes remains inland waterways." (Interviewee 2)*

Similar to the volumes and infrastructure themes, the Law Major theme will resurface in the third results chapter on the topic of a modal shift.

Different factors as perceived by the interviewees which set the context in which they make decisions on mode choice in practice have been highlighted. These included: control,

inventory stock management, on- and offloading process, production process, specific vessels, the product requirements, supply chain, volumes, peak delivery and loss and damage, safety, infrastructure, contracts and Law Major. The next section elaborates on the experiences of the respondents in relation to the SP survey and the perceived *"realism"* of the SP choice tasks compared to their transport decision-making in practice (RQ2.1, RQ2.2).

5.3.3. Freight SP "realism": putting the focus on participants' experience

This section elaborates upon the perceived *"realism"* of the stated preferences choice survey as experienced by the participants (research questions RQ2.1. and RQ2.2.).

Stated preferences surveys have been widely applied in the freight mode choice transport literature and practice, although, with recognising its limitations (see Chapter two and four). As already argued, the stated preference choice survey using CAPI (computer aided personal interviewing) lends itself easily to combine with qualitative interviewing techniques. A recorder was used to capture the qualitative interview questions and answers but was also present during the freight SP survey. Therefore, comments made during the choice tasks were also transcribed and considered as qualitative input data. In addition, follow-up questions were raised after the SP choice survey and probe questions were used to gain more insights in the comments made during the choice tasks.

The combination of the comments made during the SP and answers given to the follow-up questions resulted in interesting insights with regards to the experiences of the respondents with regards to the SP choice survey. The main insights will be highlighted according to the following SP choice survey components: **choice tasks**, **specific attributes** and the **differences between the within-mode and between-mode** set-up.

A side-note needs to be made with regards to the listed main insights. These are formed based on the interpretation by the researcher on the node coding of the transcribed qualitative data. Best practise shows that node coding with multiple researchers on qualitative transcribed text data is often desirable (Bryan, 2001), however, this is mostly done in the context of a research team. This study is a single-student endeavour. However, additional supervision was sought and resulted in a research visit to the University of Sydney (ITLS) where the student was

supervised through the qualitative process and additional workshops on qualitative research were followed.

Some exemplary quotes will again be given to support insights, however, not all relevant quotes (or coded text fragments under the nodes) are included. In addition, the insights are derived from the collective of text fragments across participants that relate to the specific sub-topics of SP *"realism"*. The quotes are translated from Dutch and kept as close to the phrasing of the respondent for the reference of this thesis. However, stop words and interjection words such as "ah" or "oh" are left out if they did not convey a negative or positive connotation.

The next section reports on the insights in relation to the choice tasks.

5.3.3.1. ***Choice Tasks***

This section addressed the research question on SP validation that aimed at understanding the experiences of the participants with regards to the *"realism"* of the choice tasks compared to their decision-making in practise. Overall, the participants expressed that the choice task environment was applicable to their current practice. However, different issues were raised which resulted in four main SP *"realism"* concerns as perceived by the respondents.

First, three respondents perceived the choice tasks not to reflect entirely their current practises in the market. They specified that existing market prices and the differences in it relating to specific modes were not reflected in the choice tasks. In addition, they emphasised the varying tonnages they work with in practice. This variety in volumes was not reflected in the choice tasks as the choice tasks were based on a single typical shipment for an outgoing transport flow and for an ingoing transport flow.

Secondly, four more participants raised the issue that their company specific production process and product range were not reflected in the choice tasks. Again, this relates to the typical shipment set-up of the choice tasks. The company requirement for multiple transport flows was stressed as multiple goods are needed for the continuity of the production. In addition, the mode choice was also linked to the implications in terms of stock management.

Thirdly, four respondents expressed that the choice tasks did not capture fully the complexity of the transport flow as it was not reflected in terms of supply chain thinking in practice, which relates to the second point raised on production process.

Lastly, two participants commented on being client-driven when making the mode choices and argued that this influences their decision-making in practise strongly.

> *"Anyhow I order everything a week in advance, then the choice is easily made. Off course when it is very urgent, and I need it tomorrow, or the production process is halted, then you choose another option off course." (Interviewee 2)* [Reflecting on the specific production process requirements that aren't represented in the choice tasks]

> *"Different factors are relevant, if it is a cheap product you might act faster, if it is an expensive one, you will spend more time on it because the inventory becomes bigger, meaning the booking value. It is not simple." (Interviewee 1))* [The interviewee links to the type of product and implication in terms of book value when asked on choice tasks resemblance to practice]

The two quotes are given as examples from a pool of quotes and relate to the issue that the choice tasks do not take into account the company specific production process and inventory stock management. In addition to the specific company production and inventory context, two respondents directly elaborated on client dependence when processing the choice tasks.

> *"I find it very hard because we do not always know what the underlying reasons are for the client, to ask for certain transport methods. I'm also thinking of delivery time, when it needs to be delivered quickly, and also the region it has to go to which plays a role for the client. And how accessible it is there." (Interviewee 9)* [The interviewee shows a client orientated reasoning when asked on choice tasks resemblance to practice]

The researcher tried to a priori address SP *"realism"* in the SP design by two measures. To obtain realistic levels of the attributes, a pivot on a reference value in a typical transport for the cost and time was used. However, it needs to be recognised that by using a typical transport with a main mode, the heterogeneity in transport flows to and from the company is indeed simplified. Relating to the type of modes, all potential and relevant found modes available in the Port of Ghent region were included for the between-mode choice tasks. It

needs to be recognised, however, that the pivot around the same reference cost value of the typical transport was used for all the modes. Ideally, market prices in relation to the different modes could have been reflected in the choice tasks. Unfortunately, access to such cost data is very difficult as this forms a competitive angle for many companies.

Resonating with the perceived issues, the SP choice tasks indeed isolated the transport flow and did not put it in a supply chain setting. However, catering for the diversity across companies in terms of production process, product range, inventory stock organisation and transport organisation requires a trade-off that needs to be made by the researcher in terms of survey length and participant engagement. The choice in this application was made to on the one hand, isolate the typical transport flow in the stated preference choice tasks with the aim of deriving policy relevant sensitivities with regards to the attributes, and one the other hand, qualitatively explore on the organisation of such transports in the interview questions to gain more understanding of the corporate context in which these mode choices are made in practice.

5.3.3.2. ***Specific Attributes***

Following upon the reflections made with regards to the *"realism"* of the choice tasks, comments were also observed relating directly to the attributes used in the choice task alternatives. The comments made by the respondents with regards to the reliability, loss and damage, CO_2 emissions and transport time attributes can be interpreted as putting further pressure on the perceived *"realism"* of the SP choice survey compared to their transport decision-making in practice. Throughout, it could be noted that the respondents took their current company transport organisation as reference point.

With regards to the reliability attribute, one interviewee stood out by questioning the acceptance of varying levels of reliability.

> *"I always reckon 100% reliability, but here [choice task] I only get 85%, I don't know if this is intended so. Is it intended so? So I choose X." (interviewee 3)*

Interestingly, this participant is observed to translate the reliability attribute (and loss and damage attribute) to a monetary cost, calculating the value aloud during the choice task and adding it up to the cost attribute. When looking at his or her individual type of choice averages across his or her choices made for the between-mode choice tasks, it can be noted that indeed the participant chose on average in his/her set of choice tasks the cheapest alternative more, but the average for choosing the most reliable is just as high as for choosing the fastest, greenest and least loss and damage alternatives (Table 23). This choice average is calculated across the set of choice tasks for the respondent, in which a value of one is given to for example the cheapest choice if the choice coincides with the lowest level of the cost attribute within the choice task.

Table 23: Choice average per type of choices per set of choice tasks made by the respondent

ID	Cheapest choosing	Fastest choosing	Most reliable choosing	Least loss & damage choosing	Greenest choosing
3	0.25	0.125	0.125	0.125	0.125

Nevertheless, the majority of participants confirmed the importance of including a reliability attribute into the SP choice tasks.

> *"Personally, it is reliability, the percentage that it arrives is very important. Because otherwise our production can't continue, so I really look at reliability" (interviewee 13).*

> *"I think if you deliver to a [name of product] producer, you can't permit loss of cargo or damage. We focus heavily on that and also heavily on reliability, because we try to differentiate ourselves from our competition on that. Then it becomes easier to make the decision, if you have extra loss, you say "dju" [Flemish interjection: negative meaning], that is extra loss and isn't smart, and if the reliability isn't good, than that is actually also bad." (Interviewee 7)*

> *"It isn't important how long a transport takes, but it has to be reliable." (Interviewee 5)*

Directly calculating the monetary value of the loss and damage attribute (aloud) while completing the choice tasks was also observed in a second respondent. This could indicate that the respondents perceived the loss and damage attribute in terms of a monetary cost.

> *"I find loss and damage also very important, because that can cost a lot of money if for example you lose 8%, in that case I go for alternative C, because I think that that 8% doesn't compensate for the [number] euro that you have to pay additionally." (Interviewee 13).*

However, the majority of respondents processed the choice tasks silently with regards to the attribute levels of loss and damage. Therefore, it cannot be concluded that this was standard practice in the sense that all participants were calculating the monetary value of the loss and damage attribute when processing the choice tasks.

In addition, another interviewee stood out when questioning and assessing the loss and damage attribute by relating the loss and damage attribute to the context of insurances. This is also reflected in his/her choices on average for his/her choice set, namely a lower average over his/her choice set for choosing the least damaged and loss alternative (0.375) compared to that of the most reliable (0.75) or choosing the cheapest (1) alternative.

> *"I think with that last thing, with the outgoing, that it is always about findings a compromise. If you say loss and damage, with us that is impossible, it's all insured and so on. Then it becomes an insurance topic." (Interviewee 4)*

However, the majority of respondents stressed the importance of loss and damage. Nevertheless, when linking the perception to the loss and damage attribute to the model results it can be noted that the attribute model coefficient repeatedly across the different model structures was not found significant (referral to section 5.2.1.2 above).

In terms of comments made by the respondents with regards to the CO_2 emissions attribute, a mixed perceived view can be noted across the respondents. On the one hand, the points raised can be synthesised as the mismatch between the hypothetical nature of including an environmental attribute expressed in CO_2 emissions clearly numerically present in the choice tasks and the respondent's current practice in which a direct CO_2 emissions variable is more absent in the decision-making. On the other hand, interviewees stressed that decisions with regards to CO_2 emissions are more difficult to make and hang together with other components, such as attributes as transport time and transport cost or even decisions made at other levels within the corporate organisation.

"But the fact today is, and it is maybe strange to say this, but emissions are of no importance. If you ask the client what they want, they will always say as less costly as possible." (Interviewee 4)

"I look at that [CO2 emissions], but it is secondary. Honestly, because the continuity, the flow, that is still important. And ok, we are in a time where we do need to look at it, we do realise that, but it shouldn't be at the expense of on the one hand, the price and on the other hand, the number of days that the transport is underway." (Interviewee 5)

"Those emissions, that is tricky for me. Because we are a big company that strongly thinks about sustainability, but sustainability has a cost. And if the difference is 2XX from 1XX, then it is too much to say I will go somewhere else for the transport" (Interviewee 6)

"Those things are guided centrally also, if I may be honest, the choice rather tends to cost, then time or CO2 emissions." (Interviewee 11)

"Some options I do not think are realistic, that you for example take inland waterways to have more pollution compared to that I work with trucks, I don't think that is possible. Because then you don't only have to take into account the emissions, but also the issue of traffic congestion. And I can't imagine fully that a truck, for me, for the environment, society, would be at any way better than a ship. And also in terms of safety, you send way more trucks per week here, you cannot guarantee that in terms of safety." (Interviewee 2)

The potential bias needs to be recognised in having the environmental attribute as directly in the choice tasks alternatives stated and thus drawing more attention to it than in decision-making in practice. However, it can also be argued from a different angle in which the hypothetical setting of the SP allows for such inclusion of a direct numerical environmental attribute from which sensitivities related to it can be derived (VO_ENV). In addition, considering the transport policy setting since the European Commission's 2001 White Paper, it doesn't seem as far-fetched to include a direct environmental measure.

Lastly, the participant's comments made relating to the transport time attribute (often put in relation to the delivery time) resulted in a diverse expressed range of perceptions. From finding the transport time (which was expressed in days) very relevant, to no relevant at all.

"Anyhow we don't have many choices in that, the transport time is still the most important" (Interviewee 6)

"For us the delivery time does not really matter, because we order on time" (Interviewee 11)

"Time and also delivery time aren't really of importance, we can for example load the truck a bit earlier, the product isn't perishable or should be super urgent. It's all a matter of having a good planning, especially for outgoing transport flows, if it is one or two days, it doesn't really make the difference." (Interviewee 4)

The transport time coefficient was consistently found significant and of the expected sign (negative) across the different choice models. However, it was concluded that no random taste heterogeneity across respondents could be noted in the transport time coefficient. This indicates that the varying perceptions present in the qualitative data are not mirrored in the choice model results.

The last component of the SP survey upon which the respondents reflected was the difference between the within-mode or unlabelled choice tasks and between-mode or labelled choice tasks. This is highlighted in the next section.

5.3.3.3. ***Within-mode vs. between-mode choice tasks***

Initially, the inclusion of both a between-mode and within-mode setting for the choice tasks was intended to make VOT (value of time) measure comparisons. Ultimately, the observed choices from both were merged to allow for model estimation. This was needed especially with regards to the more complex model structures. However, the mixed methods design of the integrated survey allowed for qualitative in-depth follow-up questions with regards to the SP. In doing so, it was asked whether or not the participants experienced the within-mode and between-mode choice tasks differently in terms of difficulty to accomplish the tasks. This question was mostly asked to invite the participants to reflect on the choice tasks they had to process, however, analysing the answers shows a diverse range across the respondents with regards to the perceived difficulty.

As above, it needs to be repeated that not all participants gave the same answers or elaborated in-depth about every topic. Therefore, the words "majority", "minority", "generally" refer only to the individuals which elaborated upon the relevant topic.

Participants' reflections with regards to the difference between the within-mode (unlabelled) and between-mode (labelled) choice tasks settings vary considerably across the different respondents, but seven respondents can be grouped around finding the within-mode choice tasks easier to process compared to the between-mode choice tasks. The main reason which is echoed across these participants is the added complexity in terms of additional trade-offs that need to be made as the between-mode choice tasks include two additional attributes: reliability, loss and damage.

> *"I found the first part [unlabelled] easier. There were more parameters in the second part [labelled]. I always reason the more parameters you have, the more considerations that you have to make. So in the second part there were more considerations to make, so more difficult." (Interviewee 11)*

> *"It became more difficult anyway, because you don't solely look at transport cost and more variables play a role. You had to think harder and make a trade-off between the transport cost, reliability and you nevertheless had to take new things into consideration. Looking at those new things and seeing if the transport cost is less important or no less important. Reliability is also such an uncertainty, also loss and damage, these are such uncertainties, this also made is very difficult." (interviewee 14)*

This is as expected as the researcher in developing the SP design always needs to make a decision in terms of the number of attributes he or she wants to include, making the choice situations more extensive/burdensome for the respondent or keeping it rather simple. A range of three up to seven attributes can be found in the SP freight mode choice literature (Beuthe and Bouffioux, 2008). Therefore, the use of three attributes and five attributes seems reasonable.

In contrast, three participants stated that they found the between-mode choice tasks easier just because of the additional information they received from the reliability and loss and damage attributes.

> *"I might have found the second [labelled] part easier, where there was more choice in options which you could take into account" (Interviewee 9).*

Interestingly, three other participants directly stated that they found the modes labelled in the between-mode choice tasks irrelevant and claimed to have made trade-offs only looking at the attributes included.

> *"No, to the 2 additional attributes. To the modes I haven't actually looked. Because as a firm, regardless of the way it enters or leaves the company, as long as it is cheap and there is no damage and it is reliable." (Interviewee 10)*

Lastly, two respondents expressed indifference with regards to potential difficulty difference between the within-mode and between-mode choice tasks.

The chapter so far has put forward insights which included the contextual setting of the mode choices in practice or put differently the perceived factors by the respondents in mode choice in practice and has elaborated upon the respondents' experiences during the stated preferences' survey in relation to SP survey *"realism"*. The question arises what the value is of taking a respondent perspective. The following section discusses this.

5.3.4. Why listen to participants? Taking a respondent's perspective

This section reflects upon why it is relevant to take a respondent's perspective in gaining understanding in the perceived context in which their freight mode choices are made in practice and why it is relevant to take into account respondents' experiences with regards to the freight stated preferences survey.

Since European policy incentives and national transport directives encourage freight transportation to shift towards modes such as inland waterways and rail, it is interesting to understand which elements decision-makers take into account when reflecting on the choices they need to make. On the one hand, the choice model results indicate how sensitive these decision-makers are to transport cost, transport time, reliability, loss and damage and CO_2 emissions, but does not cover other factors which they perceive to relate to their mode choices made in practice. Gaining understanding in such specific participant context with regards to freight mode choice might strengthen or give a different perspective upon the

derived attribute sensitivities. In this sample, model results with regards to the cost, reliability, time and CO_2 emissions coefficients were reflected in the qualitative data. Only with regards to the transport time and CO_2 emissions attribute, the qualitative insights were not fully mirrored in the model results in terms of expected random taste heterogeneity across the respondents in these attributes.

In addition, many different perceived factors came to the surface (often linked to each other) when participants elaborated on their current mode choice. Some of these factors relate to existing attributes used in freight mode choice surveys, such as safety (for example in Danielis et al., 2005), volumes or shipment size (for example in Nam, 1997), distance (for example in Masiero and Hensher, 2012) and good characteristics (for example in Vellay and de Jong, 2003). Additional factors which are case-study specific such as contracts, inventory stock management, infrastructure, specific vessel requirements and on -and offloading process to name a few are also found relevant with regards to the contextual setting of mode choice by the qualitative analysis. However, it is unfeasible to include all relevant factors in a single stated preference freight survey and the case-study specific nature needs to be recognised. Nevertheless, in terms of relevance to the case-study region these hold. In qualitative analysis, findings are conventionally argued to be case-study specific. However, due to the corporate nature it could be argued that the findings might apply more generally onto European production companies located near port locations. The findings in this application indicate that there is a potential research interest in taking production and inventory logistics into account when assessing mode choice. In particular: the inventory stock system, on -and offloading process, specific vessel type, production process and available infrastructure. In addition, these findings can result in the formation of hypothesises to test in future research.

Logistic managers of freight shipper's companies were targeted for the stated preferences survey and interview questions. The choice to proceed with logistic managers within shipper's companies as main decision-makers of mode choice was argued in the survey chapter. The qualitative derived 'control' theme revealed that some respondents are indeed in control on the mode choice, however, other respondents were observed to take a client-orientation when elaborating on mode choice. This indicates that not only the preferences of the logistic managers, but also the clients' preferences are taken into account. Therefore, it could be

argued that the logistic managers of the shipper's companies proxy the trade-off of the client. This forms an interesting track to continue on with additional research with regards to mode choice representation.

Following this, listening to respondents allows the researcher to re-evaluate his or her choices made with regards to SP design in terms of choice task setting, alternatives and attributes used.

> *"It's hard to design such a survey. Because in any case every company has different products, different ways of transportation, I mean, I only work with inland waterways and sea, so some of these questions [choice tasks] are not relevant to me at all. Or that you have to choose your reference price in the beginning, that has some purpose for you, but we do not reason here like that. Here in this company we use inland waterway transports, so I'll look for options within inland waterways. I look at different transport providers for inland waterways transports and I'm not looking within rail or road transport anymore. Especially not the road transport, I'm not going to improve with using road transport, especially not towards society, road traffic, accidents on the road, I think we do quite well with inland waterways transport." (Interviewee 2)*

The beginning of the respondent's quote says it directly: *"it's hard to design such a survey".* Designing the SP survey implies simplifying reality in which freight transport mode choices are made. By simplifying the choice tasks in the setting of a typical shipment with a main mode, a single survey was achieved that could apply to diverse freight shipper's companies in the Port of Ghent region that were targeted to participate in the survey. The conventionally used practice of pivot techniques was applied to gain realistic cost (tariff) levels and time levels (days). Also, the environmental attribute was framed around an average derived from European data (EEA, 2015) across modes and information on loss and damage occurrences from the Dutch VOT study of de Jong et al. (2004) were given prior to the choice tasks to serve as a reference point (referral to Chapter 4 on the survey). Every respondent approached the choice tasks from his or her own company point of view, which as the respondents indicated is in reality more complex than how it is put forward in the SP choice task setting. Unfortunately, placing the transport mode choice in the entire supply chain setting of a product would result in heavy data requirements in terms of company engagement. Considering the rather low response rate to this survey (20 companies which participated out of a potential targeted population of 100 companies in the Port of Ghent region), these supply

chain data requirements seem daunting. This is because not only data with regards to the transport mode needs to be collected, but also data with regards to the production and different stakeholders involved across the supply-chain. It could even be argued to be unrealistic for a study without a large funding body, as Beuthe and Bouffioux (2008) state it directly for their Belgian study: *"Firms are often reluctant to be interviewed for a variety of reasons, so, as in other similar studies, we were unable to gather a large sample"* (pp. 108, Beuthe and Bouffioux ,2008).

To end, SP freight surveys are often approached from a perspective which puts model output objectives forward, in which the estimation results derived on the sample serve as representations for the underlying population. Or put differently, the findings are generalised to the population. However, it is interesting to feed back to the underlying target population and ask the sample respondents about their experiences in such a survey. In doing so, issues have arisen that question the *"realism"* of such surveys and additional variables were put on the table by the respondents which can be considered to take towards future research on mode choice. In other words, the feed-back approach used with the participants resulted in interesting findings which could be included in future freight SP.

The next section forms the last part of this chapter and will highlight the preliminary model results with regards to integrating a subset of themes in an extended choice model framework.

5.3.5. ICLV: mode choice and themes

Perceived factors in the form of qualitative themes came to light by conducting interviews in which the participants were asked to reflect on their current mode choices made in practice. However, as any stated preferences survey is limited in the number of attributes it can include to maintain a balance between the amount of information that is derived and the cognitive burden for the respondent, it was unfeasible to include all attributes found relevant in the literature in the stated preference survey. However, model efforts were made to exploratively incorporate a selection of the derived freight themes into an extended choice model framework and thus potentially assess the impact upon mode choice. These preliminary trials will be discussed in this section.

As the qualitative thematic analysis resulted in over 60 themes, it was opted to select a subset of interest. Based on the thematic analysis (QL), different clusters containing a set of themes could be identified. As discussed in section 5.2.2, these were: company and environment, modal shift, shipment operational sphere, shipment and company organisation, policy sphere, transport formalities, shipment specifics, individual and environment, modes, client orientation and behavioural components. Due to the explorative nature, only one cluster was chosen to explore on in terms of integration with a choice model, namely: company and environment. This cluster was chosen to serve as test bed as the research interest in this application lies on the inclusion of the environment in relation to mode choice. The company and environment cluster include the following themes: green-balance-to-market, company environmental actions, compromise, green by-product, image and compromise. These will be discussed with their interpretation of the model results.

Initial modelling attempts included testing a set of themes directly into the utility functions. This implied treating the themes as if they were socio-demographic variables. However, it is argued that a latent nature needs to be recognised with regards to the themes. As the binary variables that were developed for the themes only indicate whether the participants elaborated upon the topic when reflecting upon mode choice, it was decided to treat the themes similarly to attitudes. In other words, they could potentially influence freight mode

choice, but are not directly observed. An ICLV model framework is applied to incorporate the themes, in which the binary theme variables serve as indicators.

The modelling process included running a separate model with regards to each theme (which is part of the cluster) using 500 draws, as well as increasing the number of draws up to 1000 to check for stability of the parameters. The latent variable of the theme was interacted with the transport cost, time and environmental attributes (CO_2 emissions), as well as with the rail, inland waterway and short sea shipping modes. Following the output results of the separate models per theme, only the significant effects (based upon the robust t-ratio and minimum of 10% significance level) were included in a combined model.

In addition, as the theme indicators are expressed in values of zero and one, it was tested to recognise this binary nature in the modelling process. Whereas the ICLV models (binary) that only include one separate theme converged and results could be computed, the model combining all significant effects did not. This is not surprising given the small sample size and large number of model components and parameters.

Continuous treatment of the theme indicators was also tested as an alternative to the binary treatment and produced more stable results. However, it needs to be recognised that the model presented in Table 24 still is not acceptable, with high t-ratio's for the parameters of the measurement model, which can suggest identification issues. Therefore, the estimation results are given here as a preliminary example of the explorative model process and its estimation results should be interpreted with caution. In terms of modelling efforts, the data sample size will have to be extended to enable future and more elaborate models of this kind.

Interpretable conversed estimates are presented in table 25 as (negative) Lognormal distributions were used for the random parameters of the cost, time and environmental attributes, which is consistent with previous modelling in results chapter one (5.1).

Table 24: model estimation results of the combined model for the company and environment thematic cluster

	ICLV T: bolduc norm, 1000 halton		
	estimate	t-ratio	robust t-ratio
ASCs:			
asc1	-0.1629	**-2.3**	-1.8
asc2	-0.1869	**-2.55**	**-2.64**
road	1.4122	**3.36**	**3.03**
rail	1.0964	**2.51**	**2.41**
iww	0.0378	0.09	0.11
Attributes:			
log_mu transport time	-1.9911	-4.36	-7.2
log_mu transport cost	1.2161	7.49	5.01
log_mu CO2 emissions	-4.1261	-5.59	-19.81
loss and damage	-1.7120	**-2.22**	-0.75
reliability	7.6507	**7.98**	**4.98**
Scaling parameters:			
scale_base	1.0000	NA	NA
scale_multiplier_WITH	2.2571	**2.12**[a]	1.07[a]
scale_multiplier_FINAL	2.0859	1.58[a]	0.91[a]
Interaction LV green - attributes:			
LV G - CO_2 emissions	2.2787	1.55	**4.91**
LV G - TC	0.4618	**3.74**	**6.37**
LV G - TT	-2.4637	**-3.08**	**-3.3**
Interaction LV themes - attributes			
LV greenbalancetomarket - TC	0.4015	**3.72**	**3.99**
LV greenbalancetomarket - TT	-0.5108	-1.74	***-1.91***
LV greenbalancetomarket – CO_2 emissions	1.8364	1.24	**4.13**
LV greenbyproduct - TC	0.4232	**3.26**	**2.76**
LV greenbyproduct - TT	0.0307	0.03	0.11
LV greenbyproduct - CO_2 emissions	-0.0734	-0.95	-1.15
LV companyenvironmentalactions - TT	0.3144	1.21	**1.97**
LV companyenvironmentalactions- CO_2 emissions	0.1459	0.19	0.7
LV image - TC	0.2985	**2.69**	**3.83**
LV image - CO_2 emissions	0.8785	0.99	**4.2**
LV greenreg - TT	0.8984	**2.1**	**2.45**
LV greenreg - CO_2 emissions	-1.4555	**-4.5**	**-11.54**
Interactions LV green- modes:			
LV G - rail	-0.5339	**-2.19**	**-2.78**

LV G - IWW	1.5458	**3.77**	**4.62**
LV G - SSS	0.7246	**2.04**	**2.53**
Interaction LV themes - modes:			
LV greenbalancetomarket - IWW	0.9678	**3.71**	**6.68**
LV greenbalancetomarket - SSS	-0.1533	-0.59	-0.62
LV greenbyproduct - IWW	0.2041	0.77	1.29
LV companyenvironmentalactions - IWW	-0.6803	**-3.06**	**-3.18**
LV companyenvironmentalactions - SSS	-0.4886	**-2.43**	**-2.54**
LV greenreg - IWW	-0.5176	-1.84	**-2.25**
LV greenreg - SSS	-0.4503	-1.73	-1.86
Interaction LV green - Indicator statements:			
Sigma LV G - trade-off economic welfare - environment	0.9042	**6.16**	**6.65**
Sigma LV G - other problems urgent than CC	1.2789	**6.16**	**7.71**
Zeta LV G - trade-off economic welfare - environment	0.0903	0.52	0.76
Zeta LV G - other problems urgent than CC	0.0119	0.05	0.05
Sigma LV G - employees (neg)	0.8459	**5.91**	**4.09**
Sigma LV G - green image	0.6490	**6**	**7.49**
Zeta LV G - employees(neg)	0.3009	1.38	**2.39**
Zeta LV G - green image	-0.0447	-0.28	-0.37
Interaction LV themes - indicator statements:			
sigma_lv_themes_greenbalancetomarket	0.3903	**6.03**	**7.88**
zeta_lv_themes_greenbalancetomarket	0.1873	**2.38**	**3.39**
sigma_lv_themes_greenbyproduct	0.3591	**6.26**	**3.88**
zeta_lv_themes_greenbyproduct	0.1666	1.64	1.21
sigma_lv_themes_companyenvironmentalactions	0.2174	**4.48**	**3.76**
zeta_lv_themes_companyenvironmentalactions	-0.4053	**-11.42**	**-10.04**
sigma_lv_themes_image	0.5448	**6.32**	**5.9**
zeta_lv_themes_image	-0.0537	-0.44	-0.56
sigma_lv_themes_greenreg	0.0214	**4.65**	**7.44**
zeta_lv_themes_greenreg	-0.3833	**-83.72**	**-76.88**
Identification LVs:			
gamma_lv_G_female	1.4969	**4.93**	**9.77**
gamma_lv_themes_greenbalancetomarket_female	-1.6329	**-2.32**	**-5.08**
gamma_lv_themes_greenbyproduct_female	-0.1236	-0.13	-0.57
gamma_lv_themes_companyenvironmentalactions_female	-0.6075	***-1.91***	**-4.13**
gamma_lv_themes_image_female	-0.4529	-0.3	-0.82
gamma_lv_themes_greenreg_female	0.13	**2.71**	**3.88**

LL(final)	-577.996
LL(choice model)	-443.3
Estimated parameters	61
AIC	1277.99
BIC	1546.2
Time taken (hh:mm:ss)	22:14:16.37

[a]t-ratio(1) and robust t-ratio(1)

Table 25: interpretable coefficients TT, TC and CO2 emissions (ICLV_T)

Conversion coefficients:	estimate	rob s.e.	rob t-rat
mu transport cost	-3.3740	0.8192	**4.1186**
mu transport time	-0.1365	0.0378	**3.6153**
mu C02 emissions	-0.0161	0.0034	**4.8008**

The output of the choice model variables are mostly consistent with the previous modelling results in results chapter one, however, two more significant effects are found in the ASC coefficients compared to the previous models. Individuals are more likely to choose for road and rail labelled alternatives compared to short sea shipping labelled alternatives. In addition, it can also be noted that the time attribute relative to cost became more important and the emissions attribute less important compared to the previous models.

In terms of the interaction of the green latent variable with regards to the cost, time and CO_2 emissions attributes, an additional significant effect was found relating to the CO_2 emissions attribute. The model result indicates that more environmentally friendly orientated individuals are more sensitive to CO_2 emissions, as one would expect.

Consistent with previous modelling results, more environmentally friendly individuals are more likely to choose IWW. In addition, they are also found more likely to choose the short sea shipping mode. Different to previous modelling, more environmentally friendly individuals are slightly less likely to choose rail alternatives. Previous modelling results reported that the individuals did not treat the rail mode any significantly different from the road mode. However, in the qualitative data a clear negative perception of the respondents can be noted

towards the rail mode in the Port of Ghent region, which might support the findings in the ICLV theme model.

The 'green-balance-to-market' theme indicates whether individuals elaborated upon and perceived the environmental factor in transportation as an element that needs to be in balance with market conditions. The model results suggest that individuals that did elaborate upon the topic are found more sensitive towards costs. The current transport market is characterised by being very cost competitive. Therefore, the result of cost sensitive individuals placing the environment as a factor that needs to be in balance with the workings of the market is not surprising. However, they are also found (ceteris paribus) to be more sensitive to CO_2 emissions (significance only on the robust t-ratio only on the 5% significance level).

The theme 'green-by-product' goes further than the 'green-balance-to-market' theme as the theme is formed based upon the statements of respondents which treat the environmental factor in transport merely as a by-product coming out of their transportation activity. It does not imply therefore an environmental pro-active stance with regards to including the environment in their decision-making towards modes. The model results suggest that individuals that took this point of view in their reflections are more sensitive towards costs.

Some individuals talked about the environmental actions undertaken by their companies during the interview, this comes together in the 'company environmental actions' theme. Respondents that did were found less sensitive to time (significant on 5% significance level indicated by the robust t-ratio only).

The 'image' theme indicator groups the individuals that elaborated upon potential company image gains from taking environmental considerations into account when making transport choices. The interaction effect of the image theme in relation to cost is found significant, but it is only of a small value, indicating that individuals that elaborated upon image in relation to environment in transport choices tend to be slightly less sensitive to costs.

The indicator parameters of the 'green regulation' theme clearly show issues with very large t-ratios and robust t-ratios. The 'green regulation' theme groups individuals that took into

account environmental regulation when reflecting upon mode choice decisions made in practice. Model results would indicate that individuals that emphasised environmental regulation are less sensitive to time and more sensitive to CO_2 emissions. However, caution is needed with these results.

With regards to the interaction effect of the themes with the modes, three significant effects were present. Individuals that elaborated upon the environment being a question of being in balance with the market are more likely to choose the inland waterway alternatives. In addition, individuals that emphasised environmental actions undertaken by their company are more likely to choose short sea shipping and inland waterways alternatives.

The use of the socio-demographic variable gender resulted from the modelling process as described in results chapter one. The ICLV_T model builds further on the previous model results. This implies the continued use of the gender variable to identify the model. In contrast to previous modelling results, four of the gender variables are found significant. Indicating that women are more environmentally friendly than men in the sample and tend to talk less about the environment as being in balance to the market. In addition, they tend to elaborate less compared to the base category (men) upon environmental actions taken by their companies. Again, extra caution is needed when making interpretations on the gender variable in relation to the latent variable with regards to the 'green regulation' theme. The model would suggest that women slightly elaborated less on green regulation.

It needs to be stressed again that caution is in place with these model results, as the model clearly displays issues in some of the reported t-ratios and robust t-ratios, especially in relation to the 'green regulation' theme. Therefore, the model is included in the thesis to serve as an example of initial model tests to explore the integration of binary quantified qualitative themes into a choice model framework (here: ICLV). However, the data sample size limitations need to be recognised. Therefore, further modelling efforts will require increasing the sample size.

5.4. Results Chapter Three: Modal Shift (QL)

5.4.1. Introduction

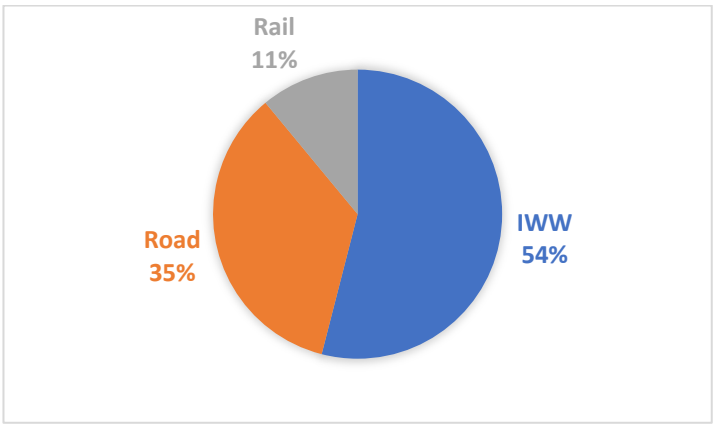
The third results chapter focusses on the third topic of this application, namely a modal shift towards more sustainable modes in which again the perspective of the interviewees is put forward. The main methodological difference with the previous results chapters one and two is the dominant qualitative orientation taken to address the related research questions (RQ3.1 and RQ3.2).

The thematic analysis resulted in a cluster for the modal shift topic, grouping eight individual themes. However, it needs to be recognised that the data did not result in a direct finding that addresses research question RQ3.2 relating the modal shift topic to the specific company context, as interviewees did not elaborate in-depth on their own company context, unless in the context of perceived barriers to a modal shift in which company experiences were shared. Therefore, it was decided to address not only perceived triggers, but also perceived barriers under research question RQ3.1. Each theme will be illustrated according to the division between perceived triggers and perceived barriers to a modal shift (section 5.4.2). In addition, these findings will be related to three identified logistical trends as listed in de Jong (2015) (section 5.4.3).

It needs to be noted that the open-ended interview question on the topic of a modal shift used the phrasing of "more sustainable modes" (Appendix, 9.3). Participants elaborated upon the modes and thus indicated which modes they understood as being more sustainable compared to the road mode. In general, either participants elaborated upon the topic in context of inland waterways or in relation to the rail mode. Only in relation to the 'infrastructure' theme or 'Law Major' theme were sea vessels also mentioned by participants. The Port of Ghent Authority set targets in terms of a modal shift by 2020, specifically including the rail, road and inland waterway modes. The Port of Ghent Authority (now called North Sea Port Authority) has set a target of having a 50% share for inland waterways (IWW), 35% share of the road mode and a 15% share of the rail mode in its modal split for outgoing flows by 2020 (Port of Ghent, 2017). Based on the publicly available

modal split numbers for 2017 (Figure 16), only the rail mode has not yet reached the target, while the inland waterway mode already surpassed it. Interestingly, the short sea mode is not included as a target for outgoing flows.

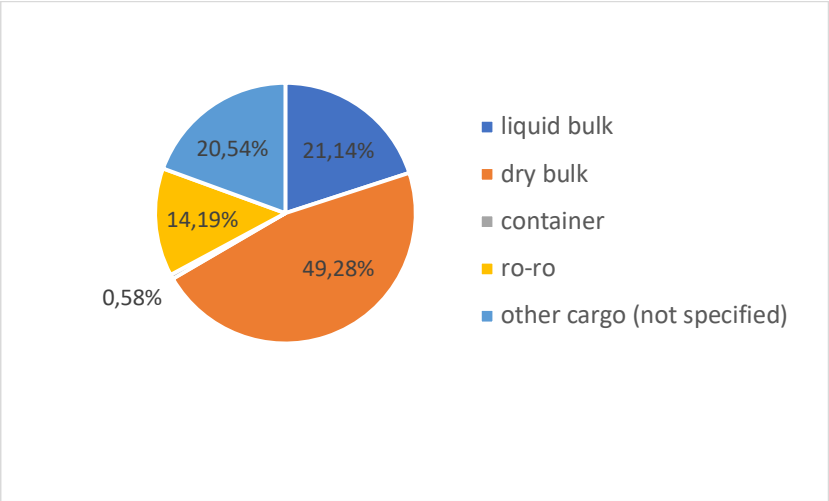
Figure 16: Modal Split Port of Ghent 2017 (outgoing flows)



Source: North Sea Port (2018)

It is also interesting to place the modal split of the Port of Ghent in relation to its goods portfolio or 'goods split'. Figure 17 presents the data available from the Eurostat database (2018). It indicates the dominance of dry bulk, followed by liquid bulk and non-specified cargo for the outgoing transport flows in 2017. The value-added nature of the Port of Ghent is again reflected in the very small percentage share of containers in the goods split. Unfortunately, the Eurostat database does not provide direct data in terms of modes used per gross weight of goods handled in European ports. However, it can be assumed that the large share of IWW can be attributed to the bulk nature of goods handled in the Port of Ghent. Modal split data for ingoing flows is not made available publicly by the Port of Ghent Authority in its documentation.

Figure 17: Goods Split Port of Ghent 2017 (outgoing flows)



Source: Eurostat (2018)

While the modal split targets of the Port of Ghent are almost reflected in the 2017 numbers, further ambitions might follow. As logistics managers of shipper's companies can be seen as the actual decision-makers on mode choices and thus potentially driving the modal shift, an interviewee-perspective is taken in the findings. The next section outlines the barriers to a modal shift as well as the triggers to attain a modal shift as perceived by the logistics managers. It will be clarified when a specific mode was highlighted by the interviewees in relation to the theme.

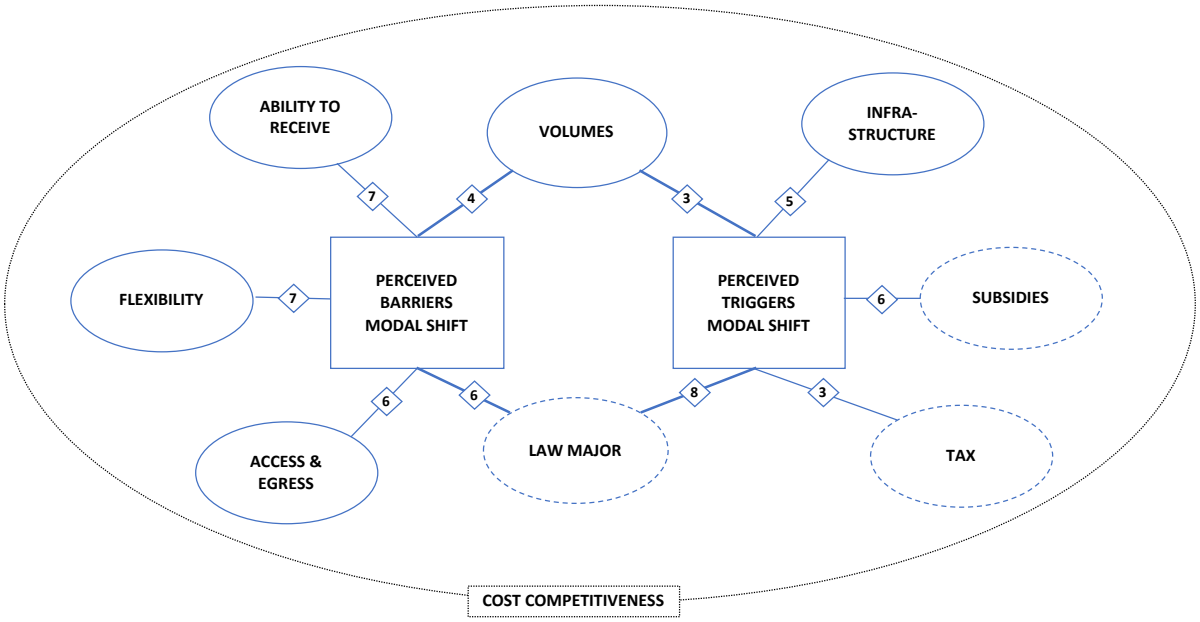
5.4.2. Perceived barriers and triggers of a modal shift

This section highlights the perceived triggers of change to attain a modal shift away from the road mode towards alternative mode such as rail, inland waterways and (only mentioned in a minority of the interviews) sea-vessels as well as the perceived barriers to such a modal shift. When asked upon their perceived triggers of change for a modal shift in the regional context of the Port of Ghent, the majority of interviewees reflected mostly on perceived barriers in which many interviewees related to their own company experiences with regards to the inland waterway mode or rail mode.

In addition, it can be noted that the interviewees kept their answers shorter compared to the length of answers given to the qualitative questions relating to mode choice. This is mostly due to reaching the allocated time limit at that interview-stage of asking the final questions. Nevertheless, the qualitative thematic analysis resulted in eight themes, divided over perceived barriers or triggers with regards to a modal shift away from the road mode to alternative modes. The thematic analysis is graphically represented in Figure 18 below. It can be seen on the thematic map that two themes were both perceived as barriers as well as triggers by different interviewees. In addition, the 'Law Major' theme, 'subsidies' theme and 'taxation' theme are characterised by a dashed lined oval. The dashed line is used to indicate the presence of strong nuance differences present within the themes. In addition, the number of interviewees grouped in the themes is indicated in the small boxes placed on the connection lines.

Three themes that indicate perceived (solely as) barriers to the modal shift away from road towards alternative modes were identified. These are: ability to receive, flexibility, access & egress. Three themes were also identified to be perceived (solely as) triggers for a modal shift, namely: infrastructure, subsidies and taxation. In addition, two themes were identified both in the context of being a perceived barrier as well as perceived trigger in relation to a modal shift, these are: volumes and Law Major.

Figure 18: graphical representation thematic analysis upon the modal shift topic



The last element that can be seen in the thematic map is the encompassing dotted line for 'cost competitiveness'. This cost-orientation taken by the interviewees when reflecting upon a modal shift was observed in almost all interviews, whether in the context of perceived barriers or triggers.

> *"A simple trigger is, what is the advantage of waterborne that's the flexibility compared to rail, but the big trigger for any is the price." (Interviewee 12)*

> *There are four individuals here that analyse routes, look for improvements and look at how we can do it more efficiently. If we are going to do it, then it needs to make sense in terms of costs." (Interviewee 3)*

Firstly, the three themes solely referring to perceived barriers will be listed, followed by the two themes which include both the perceived barriers and also the perceived triggers of a modal shift. Next, these two themes will be highlighted from the perspective of being a perceived trigger. Lastly, the three themes relating solely to the perceived triggers of a modal shift will be clarified.

A group of seven interviewees is observed to touch upon the theme of flexibility in which six of the seven interviewees related this specifically to the rail mode. The perceived strong inflexibility of the rail mode is argued by the interviewees to prevent them using or switching

to rail. In addition, specific negative experiences using the rail mode in the past are brought up by four of the interviewees. The perceived issues in terms of flexibility related to the rail mode are: in terms of the capacity related issues of the rail-network, regulation that is found to prioritise passenger's rail transportation, inflexibility to react to (short term) demands, unreliability and cost elements.

> *"I don't believe in rail, because the inflexibility of the rail mode is not something that can be solved. Already now there is overcrowding in the network. You see that it is already difficult to let transports go on time for passengers, imagine that freight rail transport would double! I really wonder where that would lead us. Only if we are looking at big investments, then maybe. The main advantage of a ship compared to rail is that from the moment you've loaded the ship it is autonomous, it can float where it wants to go in a manner of speaking. It has control of its own float-time, a train doesn't have that. A train needs to adjust very much into various schedules, which makes it utterly inflexible." (Interviewee 5)*

> *"Maybe train, but the train is never flexible enough to respond in the short term" (Interviewee 12)*

> *"With trucks yes, with rail on the contrary, 98% reliability, that's a train I still need to find. In a manner of speaking, we don't have to bring the rail mode up, our big boss of [company name] has such bad experiences with the rail mode in the past that it is not even on the table" (Interviewee 18)*

> *"It seems logical, but I have made a study a few months ago for the train to [country name]. That was off course not for daily transports, as trucks are daily and I have to say that the service we have with trucks is very fluent as we are not bound to specific hours and the delivery time is being respected. So, the trigger to switch towards the rail mode considering there were certain limitations that were slightly too big in terms of those flexibilities, and there was also the price, sometimes similar or more expensive, in the end I didn't go for the rail option." (Interviewee 19)*

However, one interviewee did emphasise rail's perceived potential advantage for re-occurring and constant transport flows. This was also mirrored in the sample size, in which companies indicating the rail mode as their main mode for a typical transport placed it in the contextual setting of mode choice with regards to fixed flows in terms of frequency and tonnages.

> *"Unfortunately, it's not easy to work with the rail mode. Freight has no priority over passenger transport. Your team is ready to start at 6:00, but the train might only be*

arriving at 9:00. Yes, you have no control over it. […]. I think that the train can work well is you are always doing the same thing continuously. Every week having a train to a destination A, then the train works. If you have to do something different every week, don't use the rail mode." (interviewee 15)

The second group consisting of seven interviewees is clustered around the 'ability to receive' theme, with a dominance towards putting the focus on the 'ability to receive' of the client. This theme indicates that interviewees perceived their own and clients' (un)ability to receive in terms of accessibility of certain modes or lacking infrastructure (see further below) to be a barrier of switching towards alternatives compared to the road mode.

"When the client can't receive it in [country name], or because there is no transport to [country name] as there are moments were there are little transport modes available. If it isn't possible, we take the road mode." (Interviewee 8)

"Unfortunately not, as it depends where we need to deliver, in which there is a limitation for the other [client]." (Interviewee 4)

"I think it's very difficult when you think of how our companies are all located. We are all in industry parks and those industry parks are often today difficult to access via waterborne vessels or trains. Only the real big companies are located at the port and are accessible by train or waterborne. That is mostly for the companies that get their materials from exterior [to the port] delivered." (Interviewee 14)

The cost element is strongly visible in all seven interviews on this theme during their given answers.

"You notice that the alternative modes aren't always cost competitive, the rail mode is in many cases not competitive, or not reliable. It is changing for a part, but our clients which aren't rail or inland waterways connected, within a range of 500 km to say something, than no, you don't get there easily with alternative modes, than you always come down to trucks." (Interviewee 14)

Two interviewees specifically specified the costs to access and egress costs when elaborating on client's ability to receive, which links to the next theme of 'access and egress'.

"In itself, the rail or inland waterways mode can be competitive, but if a client is 10 km away from the rail station and you need to organise an access and egress transport of 20 km to the terminal, that is often already lost, because that part of 20 km that you

need to drive, that costs is in a manner of speaking half of your transport cost, instead of leaving here with the truck. Well, that is lost." (Interviewee 3)

Following this link made between the 'ability to receive' theme and access and egress costs, the third group consisting of six interviewees is clustered around the 'access and egress' theme. The 'access an egress' theme differs from the 'ability to receive' theme as it only focusses on access and egress, where the 'ability to receive' theme is more general on accessibility and ability to receive goods. Dominantly, access and egress transport demands were perceived as a barrier to switching away from road to alternative modes, mostly due to the perceived increased cost factor.

"You always have an access and egress transport. And in the end, we do an inland ship from time to time once every 2 months or so, but we always drop out because of the cost." (Interviewee 5)

"So how do you solve handling costs, that stops a lot of potential flows. If you effectively get in with an inland ship for let's say four euro per ton in [location], but you have to do a transhipment of let's say five euro and an egress transport of six, well sorry, but then you better go directly with a truck to [location]. I don't really have an immediate solution for that, maybe the transhipment can go cheaper, the egress, maybe, but it's doesn't seem straightforward" (Interviewee 3)

"We see regularly people doing test, for example someone in [location] that gets 300 ton daily, around 12 trucks per day, that person does a test of getting a ship of 1200 ton to [location] and transhipment onto trucks to drive to the production unit. One can get attracted to the cheaper rate of inland waterways, and that is so, per ton it can be cheaper, but you can only be cheaper when you go from point to point and there is no transhipment or access and egress transports necessary. And those that can go from point to point, they do that with inland vessels. The problem is for those who are not located directly at the waterside, the last 10 km to get done. There are a lot of people doing tests on that. Sometimes it works, sometimes it doesn't. We are in that transitional phase." (Interviewee 12)

Four interviewees were observed to perceive current volumes as a barrier towards shifting towards alternative modes. These are grouped in the 'volumes' theme.

"I've heard of companies that want to start in the harbour, but they say it isn't feasible in terms of minimum tonnages and that not all companies can reach those." (Interviewee 2)

"I know that trains, per definition, are expensive. It's mostly interesting when it needs to go a bit further, like for example Poland or somewhere. Then you can work

intermodal, you have small part of traction to the train station, and then the full train to Poland and from there a small part of transport, that would work. But the train within Belgium. That can only work if you have big volumes coming in and out. In the past, the industries were using train, but through the years that switched towards inland waterways." (interviewee 15)

The last theme relating to perceived barriers of shifting towards alternative modes, specifically to the waterborne modes, is the more sensitive perceived topic of the current regulation of the Law Major. This theme also appeared in relation to the contextual setting of the mode choices made by the logistics managers in practice. To repeat, the Law Major regulates the handling of goods and on -and offloading of waterborne vessels in the official port region by obligating the use of officially recognised dockworkers (Flemish Port Commission, 2018). Four interviewees directly stated to find the current regulation of the Law Major as a barrier to them for using the waterborne vessels.

"That's a very important factor here, where it finally needs to come to a point of decision that we can become as competitive as our neighbouring countries, and that around that entire Major regulation, that there comes clarity. Because if that would be omitted, more inland waterways and sea traffic will come. Because I think this is stopping companies to use those, because they don't want all the fuss around it with the dockers. I think many will shift towards inland and seaborne when there is clarity around it, and also in terms of competitiveness, it will be much cheaper. I don't think that you know what kind of prices we pay here to unload a sea vessel." (Interviewee 2)

"Yes it [Law Major] stopped us in the past to work with containers. In the past we looked at to strip ourselves, install a container-put, but it would have been very costly. In addition, we didn't have the knowledge, so we would have to use dockers, which gives you an additional cost. So yes, in a way, it does stop us from shifting." (interviewee 10)

However, as the topic is divided in both opponents and advocates in the public debate, it wasn't surprising to also observe a perspective being taken from the dockers' point of view by two of the interviewees.

"It's an expensive system and I think we better look for an alternative. But I understand that this is sensitive, people have a protected status, and if I were to be a docker, I wouldn't be welcoming an alternative". (Interviewee 15)

The last two themes of 'volumes' and 'Law Major' perceived as barriers to a modal shift away from the road mode form the bridge towards the perceived triggers of a modal shift, as these were also perceived as opportunities to become triggers.

The 'Law Major' theme included six interviewees that reflected on a change in the regulation, which in their reasoning would result in a better cost competitiveness of the water-bound modes and therefore triggering a modal shift towards those modes, especially the sea vessels.

> *"I think that a change in the Law major can play a big role in terms of costs. Because we would be able to work cheaper and more flexible. Many clients say that we are not that flexible and that we adapt with difficulty. That isn't our fault, that is the system of dockwork." (Interviewee 9)*

However, not all interviewees agree with the view that a change in the regulation would result in gains in terms of cost competitiveness. Two interviewees were observed not to follow this reasoning.

> *"The Law Major, no. First the changes that will be made to the law are not really fantastic. There are measures taken to make inland waterways more attractive in Ghent, to make loading and unloading of ships with dockworkers more attractive. But the changes that will be made to the law are not big enough to change the nature of the story. It isn't going to get a lot cheaper, by the way, in the story of loading ships, an inland vessel is already cheaper to load compared to trucks. If we get a truck loading, with one worker you do roughly 10 trucks in one hour, that is nice, let's say that you can actually do 8, then you've loaded 200 ton in one hour. With a ship loading [inland] you can easily do 400 ton per hour, and that's also only with one worker. Loading and offloading is always cheaper with an inland waterway vessel and the changes in the Law Major are not going to change much in that story. There's a lot of talk about it, but that is really a storm in a glass of water [Flemish idiom, British equivalent: storm in a teacup]." (interviewee 12)*

The second theme of 'volumes' that was both perceived as a barrier in terms of minimum tonnage requirements was echoed as a trigger by three other interviewees as larger volumes being perceived better suited for a switch towards the water bound modes. Similar to the 'Law Major' theme, where the focus lied upon waterborne modes, the rail mode is again absent within this theme.

"Via water you can reach larger volumes and that is really interesting for us. The rotation of it too." (Interviewee 9)

"It's [trucks] annoying when you have a production facility that processes 300 ton daily. An inland waterway vessel of 1000 ton is then only three days production, if you have to do that with trucks than you are having a minimum of 12 trucks daily, so then you shift to inland waterways." (interviewee 12)

Five interviewees are grouped in the 'infrastructure theme', which consists of the reflections made in terms of the perceived triggers related to infrastructure. These included port expansion, warehouse expansion, terminal expansion and infrastructure expansion related to the ability to receive certain modes.

"Enough space that allows for enough expansion." (interviewee 8)

"I think what could help, maybe, is installing public quays in strategic locations, that make it possible for a location that isn't directly located at a quay to get transport flexible into a ship. A couple of public quays, like there are in the Port of Paris. You reserve them, you take your precautions in terms of safety and you can load your shit and you leave, yes, in that way it would end up in a ship, I think this in relation to our sector would work." (interviewee 18)

In particular, two interviewees in the 'infrastructure' theme reflected on the specific example of the ongoing project (building phase) of the new lock infrastructure in Terneuzen, which is a collaboration between the Flemish and Dutch authorities as well as the relevant Port authorities, now merged as the North Sea Port Authorities. The new lock, which is scheduled for completion in 2022, will provide increased connectivity for the port of Ghent in relation to the North Sea in terms of vessel size and entry capacity as larger ships will be able to enter. The lock will be 366 meters long, have a 49 meters width and 15 meters depth, which is comparable to the locks in Panama (Nieuwe Sluis Terneuzen, 2018). This lock is put forward as a trigger to increase waterborne traffic by these interviewees.

"There will be a big push with the enlargement of the project of the lock [Terneuzen]. Because we'll be able to receive bigger [waterborne] vessels, so that will be a push. If we can push to make the connection for the Seine-Nord to happen earlier, then we will do that too." (Interviewee 8)

"The only think that we think or maybe hope a bit, and that is not always our decision, is that with the new lock [Terneuzen] there will be directly more sea vessels to enter,

partly instead of push barges from Rotterdam. That could become a change of the trend." (Interviewee 7)

The operationalisation of the new lock forms an interesting research subject in terms of transport flows in relation to waterway connectivity between the North Sea, Netherlands, Belgium and France.

A group of four interviewees within the 'subsidies' theme could be observed to highlight government subsidies as a perceived trigger to attain a modal shift away from the road mode towards alternative modes. However, the theme is nuanced. It ranges from two interviewees advocating for subsidies per se, to two who advocated for subsidies only in the starting phase, which is in contrast to two additional interviewees positioned at the other end, who were observed to be more critical for subsidies or even arguing against.

"Government incentives in terms of costs. I'm convinced that the government will have to provide money, to start a particular flow." (Interviewee 7)

"Certain things that could be competitive you shouldn't subsidise, but green and certain initiatives are only possible by subsidies, of that I am convinced. I only belief in subsidies if they want to get something started which otherwise wouldn't stand a chance to create a market, but then you need to reduce and pull out as a government and leave the market to itself." (interviewee 1)

"It doesn't seem wise to me to let subsidies arrange everything, no." (Interviewee 3)

The last theme highlighted in the context of perceived triggers for a modal shift away from the road mode to alternative modes is the nuanced theme of 'taxation'. A potential carbon tax or road-based taxation were perceived as potential triggers by two interviewees. However, an opposed view was also observed with another interviewee.

"I think it's perfectly possible to tax companies on their CO_2 footprint. Now you have companies that are taxed on their business assets, which is a nonlogical trigger in this way of speaking. Now you get taxed on that, which is actually wrong. You should be taxed on your CO_2 emissions and then you'll automatically pay attention to it. It should be more a greener tax-shift compared to what we have today." (Interviewee 1)

"Introducing a road-tax isn't in my opinion the solution. The smaller stocks and this and that don't allow it that easily to shift." (Interviewee 3)

The eight identified themes were each illustrated by relating them to either being a perceived barrier or perceived trigger to attain a modal shift. However, it is interesting to look at how these regional Port of Ghent findings relate to more general logistical trends. This will be highlighted in the next section.

5.4.3. Relating the insights to logistical trends

The question arises to whether and how these qualitative findings specific to the regional Port of Ghent modal shift topic relate to general logistical trends that affect the freight modal split. The described set of logistic developments and characteristics of modes which are argued to be *"important drivers of modal split and shipment size"* in de Jong (pp. 217, 2015), who gives an overview on demand for freight transport, will be used to benchmark the identified themes. However, it is acknowledged that more logistical trends that impact the modal split have been described in the literature (for example in the work of McKinnon et al. (2015) on green logistics) and this will be incorporated in future research efforts.

The qualitative findings will first be put in relation to the listed logistic trends and secondly compared to the described mode characteristics for road, rail and waterways as in de Jong (2015).

Three logistic trends are put forward in de Jong (2015), namely: decreased unit transport costs and increased unit inventory costs which has resulted in the growth of just-in-time (JIT) transports, demand-driven production due to technological progress and supply chain developments in terms of the use of distribution centres, hub-and-spoke systems or inventory centralisation.

Firstly, the JIT transports are argued to put more focus towards quality aspects such as reliability and flexibility of the transport service which are often considered best attained by the road mode (de Jong, 2015). No specific focus was put on the just-in-time nature of the transports, but it can be assumed that the participated companies located in the Port of Ghent region are also subjected to this increasing trend. Reliability and flexibility were two factors present and stressed in the contextual setting of the logistics manager's mode

choices in practice (results chapter two) and also came to the surface when elaborating on the modal shift topic in the regional context of the Port of Ghent. The reliability factor was (across the sample) found to be perceived positively in relation to the road and inland waterway mode, but negatively perceived for the rail mode. The flexibility factor was also observed favourably for the road mode, but the inland waterway mode and especially the rail mode were perceived to perform not as strong on the flexibility demands compared to the road mode.

Secondly, demand-driven production due to technological progress is put in the context of flexible production processes and production that is based upon demand forecasts. The flexibility factor in terms of coping with the short lead-time and reliability of the transports is emphasised within this trend and linked to the road mode in terms of performance on these factors (de Jong, 2015). Based on results chapter two on the contextual setting of mode choice in practice and freight SP *"realism"*, it became clear that the respondents took their production process into account when elaborating upon their mode choices and reflecting upon the freight SP choice tasks. In contrast, based on the thematic analysis no clear identified theme on the production process was present in the sample in relation to the topic of modal shift. It needs to be repeated that the amount of available data to address the research questions formulated on a modal shift was less extensive compared to the data available for the topic of mode choice. However, the identified 'volumes' theme can be assumed to link into the production process factor, as minimum volume requirements were perceived as a barrier for shifting towards inland waterways or the rail mode. In relation to the quality aspects of the transport service, the rail mode was perceived by the interviewees as not being flexible in terms of short-term demand whereas the road mode was. This is in line with de Jong (2015).

Thirdly, the supply chain developments in terms of using of distribution centres, hub-and-spoke systems or inventory centralisation to reduce costs is difficult to link to the findings in this application as the emphasises of the qualitative interviews were on mode choice and perceived triggers and barriers to a modal shift. In other words, mostly isolating the transport from its supply chain but allowing space to let the respondents discuss the contextual setting in which they decide upon mode choices. Using this approach, it could be

derived that participants expressed the issue that the SP choice tasks did not allow for such a supply chain perspective. However, participants were not observed to elaborate upon the organisation with regards to distribution centres or hub-and-spoke systems. Nor in the context of the mode choice topic, nor in the context of the modal shift topic. The further link between consolidating freight transport flows and containerisation listed in de Jong (2015) was also not present in the rhetoric of the interviewees. However, it is argued that this is due to the dominant bulk nature of the Port of Ghent, which is also reflected in the sample.

The attributes listed in de Jong (2015) with regards to the rail and road mode are mostly reflected in the findings of this application. However, the inland waterway mode does reflect a very regional setting for the sample insights.

De Jong (2015) references a table of de Jong and Kroes (2014c) which presents an overview of the advantages and disadvantages of the road and rail mode. The listed advantages of the road mode in terms of flexibility, availability, direct point-to-point transports and reliability of the services are also echoed in this application. In addition, the perceived lack of these road-mode advantages in the rail mode are perceived as a barrier to shifting from the road mode to the rail mode in this application. The listed disadvantages of the rail mode in terms of time and cost with regards to loading and offloading as well as bottlenecks due to the competition with passenger trains was strongly echoed in this application as well. In addition to the listed disadvantages from the table of de Jong and Kroes (2014c), the strong perception of the rail mode being inflexible and unreliable is present in this application.

The waterborne modes are argued to be most compatible with low value goods and long distances (de Jong, 2015). The distance factor (and mostly the ‘volumes’ theme) was also echoed with the interviewees when elaborating upon the inland waterway mode. However, it became visible that the regional topic of the Law Major regulation was present not only in the reflections made in relation to the contextual setting of mode choice in practice, but also in the modal shift topic when relating to the waterborne modes. It was considered by some to act as a barrier for shifting towards these modes. Therefore, the qualitative insights on waterborne modes are characterised by being regionally specific.

5.4.3. Reflection

A clear difference in terms of the number of identified themes compared to the thematic analysis of the contextual setting in which mode choices are taken in practice is visible. The number of identified themes in relation to the modal shift topic is lower. This is arguably due to less rich data as interviewees only reached the modal shift questions near the end of the interview and time restrictions were mostly respected. Nevertheless, eight themes could be identified. These were perceived as triggers, barriers or both in relation to a modal shift in the regional context of the Port of Ghent away from the road mode.

Particularly, the negative perception around the rail mode surfaced strongly which was also the case in the contextual setting of mode choice (results chapter two). Further analysis in the rail network and market is advised before making policy implications in relation to the rail mode in the Port of Ghent.

From the identified themes it became clear that the opinions related to a modal shift in the regional context of the Port of Ghent are diverse. It needs to be emphasised that these findings are all from the point of view of the logistics managers only. No other relevant stakeholders were included in the sample as the main focus of the survey was on mode choice. However, from the derived themes it became clear that the topic of a modal shift is a multi-stakeholder topic including local authorities, rail authorities, national regulation, worker organisations and company stakeholders. Interestingly, across the perceived triggers the governmental factor was present, either in the form of regulation, subsidies or even infrastructural decisions which in the port mostly fall under the jurisdiction of the Port of Ghent Authority. This reaffirms the multi-stakeholder perspective needed for the relevant topic of a modal shift. Researching the interplay between these different stakeholders forms an interesting research topic but is unfortunately beyond the scope of this application.

Nevertheless, the initial barriers and triggers as perceived by logistics managers might serve as valuable input to the Port of Ghent Authority to use in discussion with different partners around the topic of a modal shift and to inform the process which formulates directions for removing barriers and creating incentives.

An additional note for future (continued) research can be made. This application took a qualitative approach to identify perceived factors by the logistics managers in freight shipper's companies located in the Port of Ghent region in relation to a modal shift away from the road mode. These insights together with the found choice model results (results chapter one) can serve as a stepping stone for a continued quantitative approach. This can include using the estimated choice models and introducing a change in one of the attributes (for example transport cost). In other words, simulating the impact of changes in an attribute on mode choice.

Lastly, when putting the findings in relation towards more general logistic trends that affect the modal split, the competitive dominance of the road mode was also found to be echoed in terms of perceived barriers to a modal shift in this application, especially relative to the rail mode.

6. Discussion Chapter

6.1. Introduction

The three main topics of the thesis (freight mode choice (DCM), the contextual setting of freight mode choice and modal shift) are addressed by using a mixed methods study design. The convergent mixed methods research design (with quantitative priority) allows for the use of both quantitative and qualitative techniques, in which integration between the two is argued to take place in the three research stages (data collection, data analysis and interpretation of findings). Integration took place during the data collection phase by interacting qualitative open-ended interview questions with the quantitative stated preferences survey. Qualitative open-ended interview questions were used to set the contextual setting of mode choice prior to the SP choice tasks, however, this was also useful to gain information to set the typical transport flow characteristics needed for the pivoted design. Also, qualitative open-ended interview questions were used as follow-up questions after completion of all the SP choice tasks to derive insights on the participants' experiences with the SP survey. In addition, it is argued that integration takes place in the analysis research phase. This is done by integrating qualitative findings and quantitative data in an integrated choice and latent variable (ICLV) framework. Lastly, integration is also argued to take place in the interpretation phase of the research as findings both derived from the quantitative choice models as well as the qualitative thematic analysis are used to complement or confront each other.

It needs to be noted that the three main topics were all approached from the point of view of logistics managers in shipper's companies located in the Port of Ghent region. Freight transport mode choice surveys conventionally differentiate between carriers and shipper's companies and identify other actors as participating in the decision-making process on freight transport choices, such as third-party logistic providers or terminal operators to name a few (Tavasszy and de Jong, 2014). However, this application identifies shipper's companies as the main drivers of the mode choice in the Port of Ghent region. Firstly, this is in line with previous research on including an environmental attribute (Fries et al., 2010) and large-scale European freight surveys such as the Dutch and Norwegian value of time surveys

(de Jong et al., 2014; Halse et al., 2010). Secondly, the geographical region of the Port of Ghent is dominated by shipper's companies as the Port of Ghent is characterised by being a value-added port.

The discussion is divided according to each main topic. However, it will be noted that results and insights derived from both techniques will be combined when relevant. In addition, the links across topics will be emphasised. The use of the word "results" mainly serves to indicate those derived from quantitative analysis, whereas "insights" refers to qualitative derived and "findings" to derived from both. In addition, recognised limitations of the research and references for future research are made throughout the discussion and synthesised at the end of the chapter.

The reflection sections provided in the previous chapters have set the tone for this discussion chapter, which is structured as follows.

Section 6.2. discusses the findings addressing research question RQ1.A on the impact of transport time, transport cost, loss and damage, CO_2 emissions and reliability on mode choice. This is followed by section 6.3., which addresses the impact of environmental attitudes on mode choice (RQ1.B and RQ1.C). Applying to both sections 6.2 and 6.3, the term "significant effects" indicates effects on the 5% significance level. It is specified if otherwise. Section 6.4. combines the discussion on the contextual setting of mode choice (RQ1.D and RQ1.E) and on the perceived *"realism"* of the freight SP survey (RQ2.1 and RQ2.2). Section 6.5 addresses the extended research question RQ3.1 by also including perceived barriers in addition to triggers on the topic of a modal shift in the regional context of the Port of Ghent. Next, section 6.6 expands on the limitations and potential avenues for future research. The discussion chapter ends with presenting key policy-relevant points based upon the research.

6.2. Transport time, transport cost, loss and damage, CO_2 emissions and reliability (RQ1.A)

The impact of the transport time, transport cost (tariff), loss and damage, CO_2 emissions and reliability attributes on the logistics managers' preferences with regards to mode choice are quantitatively assessed by applying two main choice model structures, the multinomial logit model and mixed multinomial logit model with random taste heterogeneity.

The freight mode choice studies of Nijkamp et al. (2004), Rich et al. (2009) and Rotaris et al. (2012) argue to shift away from a linear specification of the freight transport cost attribute. This is also more recently echoed in the study of Jensen et al. (2018), who found a combined linear and logarithmic specification for the cost attribute to perform better (specifically to dry bulk goods). The estimation results in this application also conclude on the use of a non-linear specification of the cost attribute. The models using a logarithmic transformation of the transport cost (tariff) were found to yield more robust model results. However, it needs to be recognised that only the normal specification or logarithmic specification were tested. In the referenced studies, other specifications were also tested, such as the Piecewise transformation as in Rotaris et al. (2012) or linear and nonlinear Spline transformation as in Jensen et al. (2018) to name a few amongst others. Future modelling efforts with regards to this application can expand by testing these.

Both in the MNL model as well as in the MMNL model, the transport time (days), transport cost (tariff), CO_2 emissions (g/t-km) and reliability (% arriving on time) attributes are found significant and of the expected sign. In contrast, the coefficients of the loss and damage attribute resulted of the expected sign but are not found significant. In the MNL model, the taste preferences across the logistics managers are assumed homogeneous. The MMNL model allows for random taste heterogeneity across the respondents in the transport time, transport cost and CO_2 emissions attributes. Both Normal and (negative) Lognormal distributions were tested for the random parameters. Setting a (negative) Lognormal distribution for the random parameters is found to yield the most robust model results. It is concluded that there is only significant random taste heterogeneity observed in the transport cost attribute. Considering data sample size limitations, it was not feasible to

explore further on the taste preference heterogeneity, for example per type of product (market segmentation) or latent class modelling. Continued modelling to address taste heterogeneity would require an increase in the sample size. Based on the qualitative thematic analysis, it would have been expected to also observe random taste heterogeneity in the transport time attribute and CO_2 emissions attributes in the model estimates as a nuanced spectrum of differing perceptions across the respondents within the 'transport time' theme and with regards to the environment reflected in themes such as for example 'green-by-product' or 'green-balance-to-market' was observed.

In terms of model comparison, the MMNL model was found to outperform the MNL model based on the loglikelihood ratio test, as well as on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) criteria.

The derived willingness-to-pay measures are discussed only with regards to the significant found attributes, these are the value of time (VOT), value of reliability (VOR) and value of environment as expressed in CO_2 emissions (VO_ENV). It needs to be emphasised that the reported willingness-to-pay measures in this application relate to the cargo component only. Or put differently, are expressed per typical shipment.

The derived VOT based on the MNL model results indicates that individuals are willing to pay 3.95 EUR for a decrease of one day in the transport time of a typical transport, which results in a willingness-to-pay of 0.16 EUR per hour to reduce the transport time per typical shipment. The derived VOTs for a typical shipment based on the MMNL model results are found higher: 6.4 EUR per day and 0.27 EUR per hour per typical shipment. To ease the comparison with European reported values in the literature, these measures were converted into values expressed per ton per hour for a typical shipment using the median value for tonnage across the sample. It is concluded that the values of 0.00033 (MNL) and 0.00053 (MMNL) EUR/t/h are much lower compared to those found in the literature. This is also the case when comparing the values only related to the water-bound modes (MNL: 0.0006 €/t/h and MMNL: 0.00062 EUR/t/h). The dominant bulk nature of the sample in this application is argued as a potential factor contributing to lower found values in this application. In addition, the qualitative thematic analysis upon the contextual setting of freight mode

choice in practice found that a group of interviewees perceived the transport time factor as irrelevant in the decision-making process in practise as it was argued to *"all come down to better planning"*. However, the qualitative insights on the factor of transport time were nuanced and some interviewees were observed to perceive the transport time as an important factor. Nevertheless, the VOTs as derived on the choice models compare lower to those in the literature.

The VOR measure based on the MNL model results indicates that individuals are willing to pay 3.49 EUR for an increase of 1% in reliability in terms of percentage of the typical transports arriving on time. Similar as in the VOT, the measure based on the MMNL model results was reported higher: 4.02 EUR. Comparing these results to VOR measures in the literature was found difficult, however, an attempt was made to compare the values with the VOR as reported in Beuthe and Bouffioux (2008). It is concluded that the VOR measure in this study is found higher. In addition, the factor of reliability was strongly present in various qualitative themes observed across the respondents. It could be concluded from the qualitative thematic analysis that reliability is perceived as an important factor determining their mode choices in practise as well as stressing its role in a potential modal shift.

The willingness to pay measures for a reduction of one tonne CO_2 emissions are 1.34 EUR (MNL) and 1.84 EUR (MMNL). Similar to the VOR, it is difficult to compare this value to the benchmark study of Fries et al (2010) as they do not include a mean reference value for CO_2 emissions and the WTP is expressed per one-percentage-point emissions reduction. It is argued in the survey chapter to present the CO_2 emissions attribute in tangible varying levels around a European average on CO_2 gram per tonne-km emitted emissions. Therefore, it is aimed that the WTP expressed in terms of a reduction of one tonne CO_2 emissions can serve as a benchmark for future freight mode choice studies that have a research interest in including an environmental attribute. The WTP values might be interpreted as hanging towards to lower end. This could be supported with the qualitative findings in which logistics managers expressed that the environment is not as directly represented as a tangible measure in their decision-making in practise. However, the perceptions ranged from not taking the environment into account in their current decision-making towards recognising the increasing importance of the environment in transport mode choices.

Lastly, it is recognised that this application simplifies an environmental attribute to the measure of CO_2 emissions. This was mainly done to be consistent with the previous study of Fries et al. (2010). The potential for future research to explore further on the inclusion of an environmental attribute in freight SP is highlighted in relation to the fields of environmental economics, ecological economics and the wider sustainability literature in which different measures (and philosophical views) on how to define and treat the environment circulate.

6.3. Environmental attitudes (RQ1.B & RQ1.C)

The impact of environmental attitudes upon mode choice is assessed by applying integrated choice and latent variable models (ICLV), using a "Bolduc type normalisation" following the work of (Bolduc et al., 2005) and Halton draws. This is done with regards to environmental attitudes relating to the individual, but also with regards to the perceived environmental outlook or "environmental attitudes" of the company. Two models are included in the thesis, a model using one latent variable on environmental attitudes and a model including two latent variables each relating to attitudes specific to the individual level or corporate level. The ICLV model including two latent variables is applied to test for the behavioural assumption that the attitudinal effect on the choice made on behalf of the company could be potentially separated in individual attitudes and how the environmental outlook of the company is perceived by the employee. Both models (ICLV 1LV and ICLV 2LV) yield interesting results.

Based on the ICLV 1LV model, more environmentally friendly individuals are found less sensitive to time and more sensitive to cost, while also being more likely to choose alternatives with the inland waterways as main mode. However, the effect with regards to the inland waterways mode was lost based on the robust t-ratio level in the ICLV 2LV model. In addition, the ICLV 2LV model indicates that more environmentally friendly individuals tend to be more likely to choose the SSS alternatives and that individuals that perceive the company more environmentally orientated are slightly more sensitive to emissions (both effects on the 10% significance level only, robust t-ratio). Based on the current ICLV 2LV model results, however, it cannot be concluded that there is a distinctive difference

between individual attitudes and how the environmental outlook of the company is perceived by the employee since most interaction effects of the environmental corporate latent variable with the attributes and modes are not found significant. A side note needs to be made with regards to potential correlation between the two latent variables on environmental attitudes (individual and corporate). Potential correlation between the latent variables was tested by introducing a Choleski factor. However, model results were not found sufficient in terms of stability of the coefficient of the Choleski factor. It is argued that this is probably linked to the limited data sample size.

Interestingly, the interaction effects of the latent variables with the rail mode are not found significant in both the models. This implies that the logistics managers with individual environmental attitudes or perceived environmentally orientated company did not treat the rail mode any significantly different from the road mode. Contrasting, European emissions data shows that the rail mode performs best in terms of percentage-share of CO_2 emissions per tonne-km compared to the other modes (EEA, 2017). However, from the qualitative thematic analysis it would have been expected to observe a choice away from rail (in the form of a negative significant rail ASC) or a negative interaction effect between the latent variables and the rail mode. The negative perception towards the rail mode became visible especially on the topic of a modal shift, where the inflexibility to respond to short term demand, unreliability of the rail service which is linked to the priority given to passenger transport and capacity issues with regards to the rail network as well as the cost elements related to on -and offloading specific trains are stressed by the respondents to act as a barrier for shifting towards the rail mode. This will be further addressed in the section (6.5) on a modal shift.

The use of the ICLV framework is argued to be two-fold. On the one hand, the research interest lies on behavioural insights into the role of underlying environmental attitudinal constructs. On the other hand, it is argued in the literature that in light of a sparse dataset (as is the case in this application), an ICLV framework or hybrid framework optimises the use of information available which could result in efficiency gains in estimation results (i.e. smaller standard errors) for any parameters that are used both in the choice model and

measurement model components (Vij and Walker, 2016). However, a critical reflection on the use of the ICLV model is in place.

Firstly, Chorus and Kroesen (2014) raise important issues in terms of forecasting when working with hybrid choice models and question the assumed causality in the models (Kroesen et al., 2017; Kroesen and Chorus, 2018). The paper by Vij and Walker (2016), while acknowledging the potential benefits, warn of the pitfalls that many applications overlook in terms of justifying the use of a hybrid choice framework. In addition, Bahamonde-Birke et al. (2017) emphasise the careful analysis that is needed when it comes to the manner in which attitudes (and perceptions) are included into choice models. It needs to be repeated that the aim of this application was not on forecasting, as no RP data was available for the Port of Ghent region and to be in accordance with Chorus and Kroesens's (2014) critique.

Secondly, the debate in the theoretical discrete choice model literature is still ongoing whether how much of the heterogeneity is attributed to the attitudes. It can be argued that the hybrid framework enforces a level of the heterogeneity in preferences upon the attitudes up to a certain degree. This issue is addressed by Hess et al. (2017, under review), in which they conclude that in their application only a limited amount of the heterogeneity can be attributed to the attitudes.

Thirdly, when comparing choice model variables between the estimation results of the MMNL model and the ICLV 1LV model with regards to the reported standard errors, no clear efficiency gains are readily visible. However, future research can explore numerically on differences in terms of statistical significance and potential efficiency gains.

Nevertheless, the use of the ICLV framework allows to assess environmental attitudes in relation to mode choice and resulted in interesting behavioural insights into the role of environmental attitudes, which can be placed in the context of a potential barrier to achieving the stated EU targets for GHG reductions and a switch to more sustainable freight modes, particularly inland water ways and rail. This will be taken to the discussion on the modal shift topic.

6.4. Contextual setting of mode choice (RQ1.D & RQ1.E) and freight SP "realism" (RQ2.1 & RQ2.2)

The qualitative thematic analysis with regards to the contextual setting of mode choices made in practice resulted in over 60 identified themes, of which all except three are clustered in different groups. However, only themes that are observed with a minimum of five or more respondents were highlighted. These are: control, inventory stock management, on -and offloading process, production process, specific vessel requirements, supply chain, volumes, peak delivery, loss and damage, safety, infrastructure, contracts and Law Major. All these themes contain identified factors that were emphasised by the logistics managers when elaborating on their decision-making with regards to mode choice in practice. Links made between the themes are often found across the different respondents. In addition, the choice model results were put in relation to relevant found qualitative insights with regards to the attributes or modes.

As qualitative research has a strong context dependent factor, the findings are argued to be relevant for the Port of Ghent region. In addition, due to the corporate nature it could be argued that the findings might apply more generally onto European production companies located near ports. The findings in this application indicate that there is a potential research interest in taking production and inventory logistics into account when assessing mode choice. Relating to logistics, mode choice studies taking into account the shipment size were highlighted in the literature chapter. However, the findings in this application indicate the potential to include inventory stock systems, types of on -and offloading processes, specific vessel types, specific production processes and company infrastructure. In terms of future research, the qualitative identified themes can also be used with regards to the formation of hypotheses to test numerically. For example, based on the control theme it could be tested whether the logistical managers in shipper's companies act as proxies for the trade-off's made by the clients. This is based on the insights that the control theme revealed that not only the preferences of the logistics managers, but also the clients' preferences and ability to receive certain volumes or modes are taken into account by a group of respondents.

The qualitative insights with regards to the perceived *"realism"* of the stated preferences (SP) freight survey reveal that overall the stated preference survey resembled with their decision-making in practice, however, important issues are put forward by groups of respondents. These are either related to the attributes used in the choice tasks, the setting of the choice tasks with regards to typical shipments or the differences between the within-mode and between-mode parts of the survey. It is argued that the degree of *"realism"* of the SP survey is taken into account during the design phase, as pivot techniques are introduced and the choice tasks are set upon a typical transport. Nevertheless, the analysis on the raised concerns by the respondents confirms the potential research interest to include production and inventory logistics in future freight SP design.

Lastly, from the thematic analysis on the contextual setting of freight mode choices in practice it could be concluded that respondents take more factors into account when deciding upon the mode choices made for their companies. While recognising the potential for future research to include these factors in freight SP, it is tested to include a selection of the qualitative themes into an extended choice model framework. One thematic cluster is used as testbed and the implementation steps include quantifying the themes into binary variables, recognising the latent nature of the themes and incorporating them into an ICLV model framework. However, model issues are found in terms of model stability and robustness. Therefore, it is argued that further modelling will require the dataset to increase as the number of parameters that require estimation are too numerous for the current number of choice observations. In addition, the same critical reflections made for the ICLV models with regards to incorporating environmental attitudes remain in this model context of an ICLV model with regards to incorporating the quantified qualitative themes.

6.5. Modal shift (RQ3.1+)

The qualitative thematic analysis with regards to a modal shift towards more sustainable modes results in eight themes, of which six described factors are either perceived as a barrier (B) or trigger (T) to attain a model shift and two themes are identified to relate to both. The eight themes are: ability to receive (B), flexibility (B), access and egress (B), volumes (B/T), Law Major (B/T), infrastructure (T), subsidies (T) and taxation (T). In addition to the eight identified themes, the notion of cost competitiveness is overall present across the different interviewees when elaborating on the topic of modal shift. A clearly visible difference is noted in terms of number of identified themes between the thematic analysis (TA) on the contextual setting of mode choice in practice and on the modal shift. The TA relating to the modal shift topic resulted in a smaller number of themes. It is argued that this is due to the underlying interview data which is less extensive compared to the available interview data on the contextual setting of mode choice in practice.

It is found that most of the identified themes either relate to the rail or inland waterways mode as compared to the road mode. If possible, the modes are specified per theme in the insights overview. Throughout the themes, the rail mode is found to be perceived negatively on multiple factors. The stated issues are with regards to the reliability of the service, flexibility and cost competitiveness. These are perceived as barriers for using the rail mode in their current mode choices, but also in the context of a modal shift in the Port of Ghent region. The identified themes specifically relating to the rail mode can serve as a first step towards researching the role of the rail mode in the modal shift topic for the Port of Ghent region. However, further analysis in the rail network and its capacity as well as the rail market is advised before making policy implications. In addition, the found insights with regards to the rail mode are in line with the work of de Jong (2005). The different themes are put in relation to three described logistic trends and are found in general to be in line with these trends as described in de Jong (2005). However, not all trends could be addressed as easily as the sample consists of producing freight shipper’s companies mainly shipping bulk products.

It is emphasised that the main approach chosen to address the modal shift topic is qualitative. However, combining the qualitative insights with the findings from the quantitative choice modelling can result in future research endeavours. Based on the choice model results, willingness-to-pay measures of 1.34 EUR (MNL) and 1.84 EUR (MMNL) for a reduction of one tonne CO_2 emissions are established. In addition, the qualitative findings suggest that the reliability and flexibility of a service are important factors in deciding upon mode choice, while the role of the environment is found more nuanced across the respondents. Willingness-to-pay measures of 3.49 EUR (MNL) and 4.02 EUR (MMNL) for an increase of 1% in reliability in terms of percentage of the typical transports arriving on time were noted. Also, the ICLV model results suggest that more environmental orientated individuals would be more likely to choose inland waterways, but not the rail mode. From the qualitative analysis it became clear that the rail mode is overall perceived negatively. Considering the combination of these findings, further research could include simulating the impact of attributes (such as emissions and reliability or cost) upon mode choice.

Similar to the analysis on mode choice (DCM) and the contextual setting of freight mode choices in practice, a perspective of the logistics managers is put forward in the analysis on modal shift. Based on the insights, however, it became clear that the question of a modal shift has a multi-stakeholder nature. This can be taken into account for potential future qualitative research on the modal shift dynamics related to the Port of Ghent region.

6.6. Limitations and future research

The main limitation in this research which is echoed throughout the thesis is the limited data sample size of 20 companies that participated. Still, this is a substantial fraction of the relevant total population of about 100 identified companies. In addition, all the main sectors are represented in the sample ranging from automotive, food, chemicals, steel etc. Also, the important players defined in terms of production volumes, employment rate and coverage in the Port of Ghent region are also included in the sample. Nevertheless, having only interview data on 20 decision-makers resulting in 600 choice task observations poses particular limitations related to both the quantitative and qualitative approaches followed in the mixed methods design. However, the boundaries of having a small dataset are more distinctively visible for the choice modelling components of the thesis.

The main limitations encountered and future research opportunities are depicted in the following paragraphs. These are structured per approach followed, quantitative (6.6.1.) or qualitative (6.6.2).

6.6.1. Limitations and future research avenues related to the quantitative components

Twenty decision-makers that resulted in 600 choice observations is a lower number for choice modelling estimation than conventionally found in the freight mode choice literature. Whereas simple mode choice estimation in the MNL did not trigger difficulties, more complex model structures including multiple parameters in the MMNL and especially relevant for the ICLV model structures showed signs of difficulty. These were openly reported and discussed in the results chapters. However, it was argued that the mixed methods (MM) approach resulted in more consistent choice observations across the participants as the MM design increased participants' engagement to the choice survey. Nevertheless, having only 600 choice observations available and more importantly only 20 observations per attitudinal indicator, resulted in issues in terms of model stability or even

model convergence. The environmental attitudinal profiles and thematic latent themes per respondent were therefore limited and with only 20 observations varying across the full data-set, the factor analysis was not statistically sufficient and the ICLV model encountered identification issues, as was to be expected. It is acknowledged that using the factor scores resulting out of factor analysis in the ICLV model structure is best practice in the literature.

As model difficulties were expected with the available data-set, a step-by-step modelling approach was followed by adding complexity incrementally with every step. Each model was building further on previous model results going from MNL to MMNL to finally ICLV. Again, the model tests and issues were recognised in every result section including choice models. To sum up the issues, these were: the limited testing of non-linearity in the attributes (only logarithmic specifications were tested), the limited tests of different distributions for the random components in the mixed logit models and the limitations of the ICLV framework with its corresponding identification issues and results that need to be interpreted with caution. To address these limitations, the research sample size would have to be increased. If so, future research would aim at the following points.

Relating to the transformations used in the utility specifications of the attributes, future model efforts can include testing for additional non-linear transformations in the transport cost attribute that are reported in the freight literature, as only Normal or Lognormal transformations were tested in this application. In addition, non-linearity in the utility specification of the other included attributes could also be tested.

Relating to random taste heterogeneity picked up by the MMNL model, testing per sector or product type for potential taste heterogeneity (market segmentation) could be undertaken and latent class models could be tested. It needs to be stressed that segmentation per sector and product is currently not possible with the current dataset because there are not enough participants per category.

Relating to the ICLV models including environmental attitudes, efforts can be directed at numerically assessing potential efficiency gains in terms of lower standard errors as theoretically claimed by the paper of Vij and Walker (2016) as well as expanding on the

behavioural hypothesis that two potential distinct environmental influences (attitudes specified on the individual and corporate level) might be impacting the mode choice which is made on behalf of the company and the potential correlation between the latent variables.

Relating to the integration of themes into an extended choice model, an additional number of clusters (which are derived on the thematic analysis) can be tested in the ICLV framework. Also, as only a binary treatment or quantification of the qualitative themes was trialled, future efforts could be directed in exploring other quantification methods for integrating the qualitative themes.

In addition, the robustness of the model results and their statistical significance needs to be placed in the context of transferability of the model result and the derived willingness-to-pay measures. As described in the thesis, not only the significance but also interpretational meaning of the results was taken into account when discussing the different model results and the derived willingness-to-pay measures. The question of the transferability of the results can be approached from two angles.

On the one hand, to what extend the choice model outputs could be related to other European inland ports. Importantly, this would require similar characteristics of the ports considered such as the inland location and more importantly the nature of the port being a value-added port. For example, generalising the results to the inland port of Duisburg in Germany would not be advised as the port of Duisburg has a strong container-handling nature. Caution is needed when making attempts to generalise the choice model results to European inland ports and the author is hesitant to do so. However, it can be repeated that there is scope to transfer the mixed methodology when conducting SP in freight-handling inland ports as it not only results in policy-relevant measures derived upon choice modelling results, but also interesting case-study dependent insights. In addition, considering the North Sea Port merger, it would be interesting to merge the Port of Ghent dataset with new data coming from shippers companies located in the Zeeland Seaports area. In terms of future research, it would be interesting to compare the results of the Port of Ghent region case-study with other inland European ports that are characterised by being value-added ports.

On the other hand, when comparing willingness-to-pay measures, it is important to also include measures of the statistical robustness of these estimates, in terms of standard errors and derived measures such as t-ratios and confidence intervals. It is acknowledged that the willingness-to-pay measures derived and reported in this thesis only consist of point estimates and do not include such measures. The most theoretically correct approach to use would be the Delta method, as discussed for choice modelling by Daly et al. (2012), while various alternative approaches have been discussed for example by Gatta et al. (2015). Specifically related to studies with small sample sizes, Gatta et al. (2015) conclude on the use of the Fieler method and likelihood ratio inversion method as best fit to gain confidence intervals for willingness-to-pay estimates. Considering the small choice dataset in this research, it would be interesting to follow-up on this in future modelling.

Lastly, the manner in which the environment was taken into account in the stated preferences surveys is questioned as it was simplified to a tangible measure in terms of CO_2 gram per tonne-km varying around a European average across modes. The choice to use CO_2 emissions was made to be in line with previous work of Fries et al. (2010), however, the measure of CO_2 emissions is not expressed in percentage changes with regards to the status quo as in Fries et al. (2010) as participants in the pilot survey expressed issues in terms of interpretation of such a measure. In doing so, it is acknowledged that the environment is therefore limited to CO_2 emissions and did not include the fuller spectrum of greenhouse gas emissions or other measures to account for the environment. Future research can aim at analysing existing measures and concepts of the environment in environmental economics, ecological economics and the wider sustainability literature and elaborating on the potential incorporating of these into freight SP.

6.6.2. Limitations and future research avenues related to the qualitative components

The main limitation relating to the qualitative approach resulted from the analysis relating to the topic of the modal shift. Only logistics managers of shippers companies were included in the interviewee sample consisting of 20 individuals. However, it is argued that the focus of the research lies upon the perspective of the logistics managers of shipper firms and it can be stated that a number of 20 conducted interviews is within the acceptable range which is conventionally stated in the qualitative methodology literature. In addition, the mixed methods design is one of quantitative priority in which the choice model component is prioritised. Nevertheless, it is concluded from the thematic analysis that the topic of a modal shift in the region of the Port of Ghent encompasses multiple stakeholders, especially in relation to the waterborne modes under the Law Major but also with regards to the rail mode and its operators. Achieving a further modal shift towards rail and waterborne modes would require all relevant stakeholders around the discussion table, which includes the institutional regulatory deputies, government, the Port Authority, worker associations and unions, company associations and individual companies located in the Port of Ghent region. This will be re-addressed in section 6.7 below. In addition, analysis upon the rail capacity and network availability in relation to the Port of Ghent and potential destinations would be required to assess the perceived barriers in this application with regards to the rail mode.

As described, the modal shift topic was approached using a qualitative method at this point. However, future research endeavours can include a simulation analysis of changing attribute values in the choice models. In addition, the qualitative analysis on the modal shift topic could be expanded by applying a multi-stakeholder perspective.

Two future explorations can be identified to the qualitative topic of mode choice in practice. On the one hand, the derived qualitative insights point at linking production and inventory logistics to mode choice (DCM) and freight SP. The manner on how and to what degree these can be added forms an interesting topic for future research. On the other hand, the findings with regards to the control theme indicated that logistic managers of freight

shippers companies could potentially serve as proxies for their clients' preferences as the logistical managers were observed to elaborate on the availability, accessibility as well as the preference of receiving mode of their clients. The field of joint-decision-making could serve as a starting point in testing this, in which the studies of Hensher and Pucket (2007) and Hensher, Pucket and Rose (2007) have modelled the interactive element in choices between transporters and shippers. However, the emphasis in the control theme lies on the shipper company and their client to whom the goods are shipped. When testing if freight shippers could serve as proxies for their clients' preferences, a choice set that links the shippers companies' choices to the choices made by their clients would be ideal.

6.7. What is the take-away for policy-makers?

On the one hand, the research reports on significant choice model results and derived wiliness-to-pay measures which indicate sensitivities in the preferences of logistical managers in shippers companies located in the Port of Ghent region towards costs, time, reliability and to a smaller extent the environment as expressed in CO_2 emissions. In addition, extended choice model results imply that more environmentally orientated logistical managers are more likely to choose inland waterways and to an extent short sea shipping, but do not treat the rail road any significantly different from the road mode. The local policy level of the Port of Ghent, now called North Sea Port, envisions a continued modal shift towards the waterborne modes and the rail mode. Questions can be pointed towards how to best achieve this.

On the other hand, the research found nuanced views on the inclusion of the environment in freight transport mode choice and reflected an image of both opportunities to achieve a modal shift, but also barriers that are perceived to prevent switching behaviour. These insights are important when answering the question how to achieve a modal shift.

In other words, the story for the local policy level is one of pulling both from the quantitative results and qualitative insights. Three main recommendations are listed below that include points that can be taken away by policy decision-makers.

1. It has become clear from the choice models that logistic managers are sensitive to costs, time, reliability and to some extent the environment as expressed in CO_2 emissions. However, the qualitative analysis enriched the results with regards to the time attribute and portrayed an image that reliability is of higher importance when deciding upon mode choice. This is in line with the reported value-of-time which is lower than found in the freight mode choice literature and a reported value-of-reliability which is in line with literature. The reliability for both rail and the waterborne modes can serve as topics of further assessment in which the guarantee and improvement of the services is key.

2. Specific to the waterborne modes, the choice models indicate that more environmental orientated logistic managers would be more likely to choose for the waterborne modes. However, these results need to be interpreted with caution as modelling issues in terms of stability and identification were encountered. In addition, the qualitative analysis reflected the sensitive topic of the very context specific Law Major which was perceived as both a barrier and opportunity to a modal shift. It is recommended that a round-table would be organised bringing all relevant stakeholders together: companies' representatives, the port authority, employees and employers unions, dockworkers representatives and other relevant regulatory bodies.

3. Specific to the rail mode, a strong negative perception was visible with the logistic managers. This ranged from questioning the existing infrastructure, the availability of rail vessels and their traceability, to reliability of the service, the prioritisation of passenger transport over freight transport and other perceived cost elements. Also, rail operators and government bodies were identified by the logistic managers as stakeholders in the debate on switching towards the rail mode. Based on the

qualitatively derived results, two lines of action could be advised. The first action point is centred around informing the companies located in the port region on best-practises case-studies using the rail mode. The second action point is centred on developing a strategic roadmap in the port area to shift to the rail mode. It is advised that the process in achieving such a roadmap would require including the companies, rail operators and the relevant government bodies in its development. Also, further quantitative impact analysis with regards to the rail connectivity in the Port of Ghent area is advised.

To conclude, the debate on green logistics is and will become increasingly important. Not only for the policy side, but also for the players in the market. Considering the share of the transport sector in global emissions that are reported in international reports which are becoming visible and openly shared in the public debate (f.e. International Panel on Climate Change reports), it is not farfetched to expect that this will steer policy-making and shift business towards more and more integrating principles of green logistics in their business operations. One of the aspects in the debate emphasises a modal shift, in which government and the private sector can tackle the questions of barriers and opportunities to achieve such a modal shift through strategic partnerships. This thesis sought to add to the local debate of the Port of Ghent region in terms of understanding mode choice of logistic managers of shippers companies, but also understanding the views coming from these decision-makers with regards to a modal shift. To move to the questions of how to best achieve this modal shift, it is crucial to bring all relevant players to the table and draft clear strategic roadmaps which could provide a window for strong public-private partnerships.

7. Conclusion

The thesis presents a mixed methods (MM) freight study in which both quantitative (choice modelling) and qualitative (thematic analysis) techniques are applied. Integration of the two techniques is argued to take place at the data-collection research phase by using an integrated survey design combining stated preferences choice tasks, qualitative open-ended interview questions and an attitudinal questionnaire. Integration also takes place at the data-analysis research phase of which the preliminary results of an integrated choice and latent variable (ICLV) model including qualitative themes are presented. Lastly, integration takes place at the interpretation research phase in which findings are combined to strengthen or nuance on and another. However, the MM study follows a convergent design with quantitative priority. This implies that more weight is given to the quantitative technique applied and interpretation of the quantitative results.

The Port of Ghent region is presented as case-study. The port is put forward as a value-added port and is typified by mainly handling dry bulk. It is characterised by its inland location and connectivity via waterways towards France, the Netherlands and the North Sea. It includes the road mode, rail mode, waterborne mode and pipelines in its modal split capacity. The accessibility of waterborne vessels to the port entering via the nautical connection of the North Sea are currently limited by the lock capacity in Terneuzen. However, a new lock is currently under construction which will allow for larger sea-bound vessels to reach the Port of Ghent. During the timeframe of the research, the Port of Ghent merged with the Ports of Zeeland and Vlissingen (Zeeland Seaports) resulting in the North Sea Port. This provides interesting research opportunities to assess the potential economic, social or environmental impacts of such a merge.

The mixed methods freight study addresses the impact of key-identified variables (transport cost, transport time, reliability, loss and damage, CO_2 emissions and environmental attitudes) on logistics manager's preferences with regards to mode choice, gains insights on the perceived *"realism"* of the SP choice tasks, gains in-depth understanding of the company contextual setting and perceived factors of importance in which such mode choices are made

in practice and lastly gains an understanding to the logistics managers' perceived barriers and triggers to attain a regional modal shift.

The impact of transport time, transport cost (tariff), reliability, loss and damage and CO_2 emissions on mode choice are assessed applying choice modelling techniques. The choice to include transport time, transport cost (tariff), reliability and loss and damage attributes is based on the freight mode choice literature review. An environmental attribute is included as it is argued that the inclusion of such an attribute will in practice play an increasing role, because of the time-line set to achieve the policy targets relating to GHG reductions from freight transportation as well as the ambitioned freight modal shift away from road to rail and inland waterways. It was opted to express the environmental attribute in terms of CO_2 emissions, in order to be consistent with previous studies in the freight mode choice literature and based on insights derived in the pilot study. However, the simplification of the environment to a single type of emission is recognised as a limitation. Potential future research opportunities on how to include the environment in freight SP are emphasised. The model results of the multinomial logit (MNL) model and mixed multinomial logit model allowing for random taste heterogeneity across respondents (MMNL) yield significant coefficients for the transport time, transport cost, reliability and CO_2 emissions attributes. These are all found to be of the expected sign. In addition, the MMNL model concludes that there is random taste heterogeneity across respondents with regards to the cost attribute. Based on the qualitative analysis, it would have been expected to also observe random taste heterogeneity across respondents with regards to the transport time and CO_2 emissions attribute, because a nuanced image could be observed relating to both attributes as described by the respondents. Unfortunately, due to data sample size limitations, neither further taste heterogeneity analysis in terms of analysing per sector (market segmentation), nor elaborate latent class modelling was undertaken. Willingness-to-pay measures such as the value of time (VOT), value of reliability (VOR) and value of environment (VO_ENV) were reported. Even though the loss and damage attribute coefficients were not found significant, the values of loss and damage (VO_LD) were also included for reference. Interestingly, the VOT in this application was found to be much lower than the reported VOT measures (relating to the cargo component only) in the literature. It is argued that this is partly due to the dominant bulk-nature of the sample. In addition, the qualitative findings suggest a very nuanced

spectrum of perceptions relating to the importance of transport time in mode choice decision-making in practice: a group of respondents did not perceive transport time as relevant at all, since it *"all comes down to good planning"*. The model coefficients and willingness-to-pay measures derived from the model results reveal that the MNL model slightly underestimate these compared to the MMNL model. In addition, the MMNL model is found to perform better in terms of model fit.

The impact of environmental attitudes is assessed by recognising the latent nature of such psycho-metric constructs and implementing them in an ICLV model framework. Significant interaction effects of the environmental attitudes with the cost and time attributes as well as inland waterway and short sea shipping modes were found. More environmentally friendly respondents are found (ceteris paribus): more sensitive to costs and less sensitive to time, more likely to choose the inland waterway mode and the short sea shipping mode (SSS only on the 10% significance level). The behavioural hypothesis that potential distinctive effects between the environmental attitudes, relating to the individual making the mode choice, and the perceived company environmental outlook ("corporate attitudes") on whose behalf the mode choice is made, did not result in clear distinctive model results. The only distinctive effect relates to the interaction of the latent variable specified on the corporate level and the CO_2 emissions attribute, which implies that individuals that perceive their company to be more environmentally friendly are more sensitive towards CO_2 emissions (only on the 10% significance level).

Interestingly, it was found that the rail mode was not treated any significantly different from the road mode throughout the choice model findings. This is unexpected, since the rail mode performs best in terms of CO_2 emissions per tonne-km based on EU data. However, the rail mode was found to be perceived negatively in the qualitative findings. The participants expressed issues related to the availability, accessibility and reliability of the rail mode as well as the rail network's capacity.

The limitations of SP choice data are acknowledged in the thesis. However, it was argued that SP was appropriate as no RP data was available in the region and SP allows for the collection of multiple choice observations, which is an advantage when facing a compact total

population size. Overall, the choice tasks in the stated preference survey were perceived to resemble with mode choice decision-making in practice. As expected, a group of participants raised concerns in terms of the perceived *"realism"* of the choice tasks compared to their decision-making in practice. These concerns were grouped according to the attributes, the choice tasks, or the difference between the within-mode and between-mode settings. Pivot techniques were applied in the SP design to increase the level of *"realism"* of the SP choice tasks with regards to the transport time and transport cost (tariff) attributes and cognitive reference points were provided to the respondents by displaying data on loss and damages and CO_2 emissions prior to the choice tasks. Nevertheless, the analysis on the concerns raised by the respondents suggests considering the inclusion of production and inventory logistics in freight SP design. This can be explored in future research.

The thematic analysis of the transcribed qualitative interview data resulted in the identification of over 60 themes which were found relevant in making mode choices in practice. The themes highlighted are: control, inventory stock management, the on -and offloading process, the production process, specific vessel requirements, the supply chain, volumes, peak delivery, loss and damage, safety, infrastructure, contracts and Law Major. Only themes that were observed with a minimum of five or more respondents were discussed. Based on the qualitative findings, it could be concluded that there is a potential research interest in taking production and inventory logistics into account when assessing mode choice. In addition, the qualitative analysis revealed that the mode choices made in practice are perceived as depending on many of these factors, which are often linked to each other. For example, the specific inventory stock facilities of a company are connected to the either volatile or stable volumes and delivery demands towards their clients. This determines the use of certain modes that can address these inventory and delivery needs.

From the thematic analysis (TA) on the contextual setting of freight mode choices in practice, it is concluded that respondents take more factors into account when deciding upon the mode choices made for their companies. To assess the impact of these on logistics managers' preferences in relation to mode choice, an ICLV framework is applied. It is argued that this framework is the most appropriate, since it acknowledges the latent nature of such qualitative themes. The qualitative themes were transformed to binary dummy variables and served as

the indicators for their corresponding underlying themes. The ICLV model yielded significant interaction effects of the themes with the attributes and modes. The model results suggest that (ceteris paribus) individuals who considered the environment to be a factor in mode choice that needs to be in balance with the workings of the market (theme: green-balance-to-market) are found to be more sensitive towards costs and more likely to choose inland waterways alternatives. Similar, individuals that merely see the environment as a by-product from their transportation activity (theme: green-by-product) are found to be more sensitive towards costs. In contrast, individuals that (ceteris paribus) emphasised their company's potential image gains from taking environmental considerations into account when making transport choices (theme: image) were found to be slightly less sensitive to costs, but also more likely to choose inland waterways and short sea shipping. In addition, individuals that (ceteris paribus) were observed to elaborate on environmental actions undertaken by their companies during the interview were found to be less sensitive to time (only on the 5% significance level). However, issues in terms of model stability were encountered. Therefore, the ICLV model integrating such qualitative themes only serves as a preliminary finding, since it is acknowledged that additional data is needed to attain more robust models.

Thematic analysis of the qualitative interview data considering the regional freight modal shift towards more sustainable modes resulted in the identification of eight themes, either perceived as triggers, barriers or both. These are: ability to receive, flexibility, access and egress, volumes, Law Major, infrastructure, subsidies and taxation. Across the themes, these were either directed to the rail mode or inland waterways mode. Similar to the TA on the contextual setting of mode choice decision-making in practice, the rail mode was found to be perceived negatively in terms of reliability of the rail service, flexibility, capacity of the rail network and cost competitiveness, which all act as perceived barriers in the switch towards the rail mode. Future research in terms of the rail network and its capacity in relation to the port of Ghent is therefore advised. In addition, it is advised to inform on and distribute best-practises case-studies using the rail mode in the port region and develop strategic roadmaps to shift to the rail mode including all relevant stakeholders in its process. In particular to the inland waterways mode, the politically sensitive topic of the Law Major was strongly perceived as a barrier for switching to the inland waterways mode in the Port of Ghent region. However, from the TA on the modal shift interview data, it became clear that the topic has a multi-

stakeholder nature involving local authorities, rail authorities, national regulation, workers stakeholders and company stakeholders. Therefore, it is advised that a round-table is facilitated that brings all relevant stakeholders together. This multi-stakeholder perspective can be taken into account in future qualitative research on the modal shift dynamics related to the Port of Ghent region. In addition, future quantitative research can address simulation of the impact of changes in an attribute on mode shares.

Both the quantitative choice modelling techniques as well as qualitative thematic analysis techniques take the logistics manager's preferences or perceptions as the central point of view. In terms of assessing the impact of the key-identified variables on freight mode choice, it can be found in the freight mode choice literature that the decision-maker is conventionally simplified to the logistics manager. The choice to follow shipper's companies and not carriers (as also found in the freight mode choice literature) was argued in relation to the type of choice that includes an environmental attribute to which shipper's companies are argued to be potential key-drivers. In addition, shipper's companies were selected as the region consists mainly of shipper's companies in the Port of Ghent due to the added-value nature of the port. However, it is acknowledged that freight transportation often includes multiple actors. In terms of addressing the regional modal shift topic, it is important to understand the barriers and triggers perceived by the actual decision-makers in practice on mode choice as this can inform the regional policy-level in their policy-decision making. The multi-stakeholder nature in the modal shift discussion needs to be emphasised and future research is needed to attain a fuller picture with regards to all of the relevant stakeholders engaged in a potential modal shift in the Port of Ghent region.

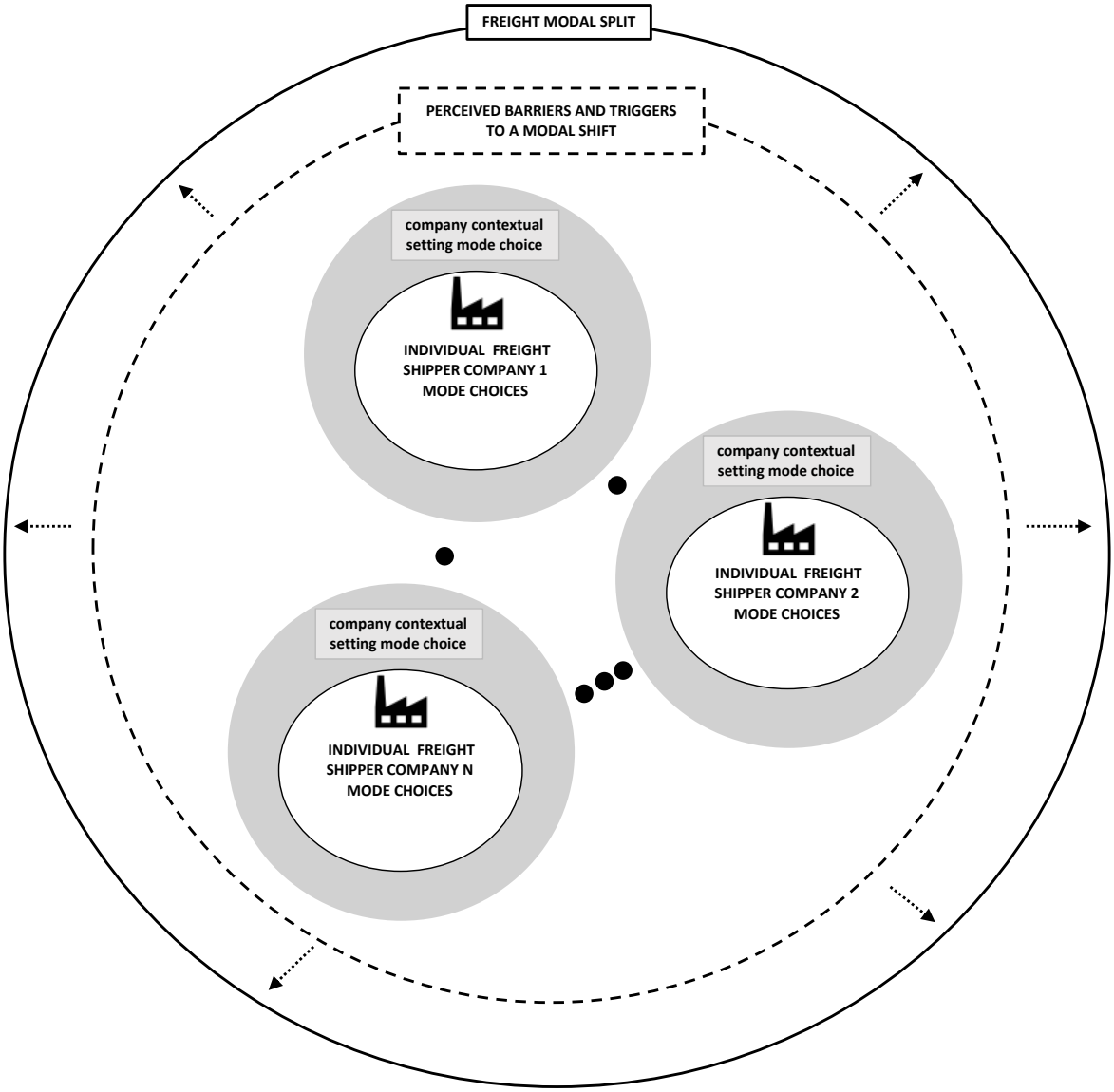
Considering European and national policy-set targets to achieve a modal shift away from the road mode towards the rail and inland waterways modes and specific GHG targets set on a reduction originating from transport, it is likely that the environment will play an increasing role in decision-making on freight transport mode choices. The emphasis of the research lies on the individual decision-makers in shipper's companies. Their perceptions towards which factors are important when deciding on mode choices in practise and perceived barriers or triggers to switching to alternative modes away from the road mode are taken into account when making these freight mode choices in practise. Collectively, these mode choices

determine the modal split. Therefore, the insights and results of this study serve to inform the local policy-level in their decisions towards freight modal shift incentives. The mixed methods freight study is conceptually and graphically summarised in Figure 19. It shows the different layers present in the research around the centrally placed freight shippers.

The thesis laid out different avenues with regards to future research. Firstly, future research avenues were highlighted specifically to the application. Additional analysis on the use of non-linear transformations in all the attributes can be tested, as well as increasing the types of non-linear transformations applied. If additional choice and attitudinal data is collected, further analysis on random taste heterogeneity and numerically assessing the theoretically grounded advantage of potential efficiency gains by applying an ICLV frameworks could be performed. In addition, an increased sample size would allow for more elaborate integration of the qualitative themes into choice modelling frameworks, in which correlations between the latent themes could be assessed. Considering the qualitative analysis on the modal shift topic, future qualitative research can aim at applying a multi-stakeholder perspective and quantitative research can focus on simulating the impact of changing attribute values in the choice models.

Secondly, future research avenues were highlighted relating to the freight mode choice literature and SP freight survey design. Future research can further link production and inventory logistics to mode choice (DCM), as these are strongly echoed throughout the qualitative analysis. In addition, future research can also look at the of inclusion of these for freight SP choice tasks settings. Also, future research can investigate the potential of incorporating existing measures and concepts of the environment in environmental economics, ecological economics and the wider sustainability literature into the research on freight SP.

Figure 19: graphical and conceptual representation of the MM freight study



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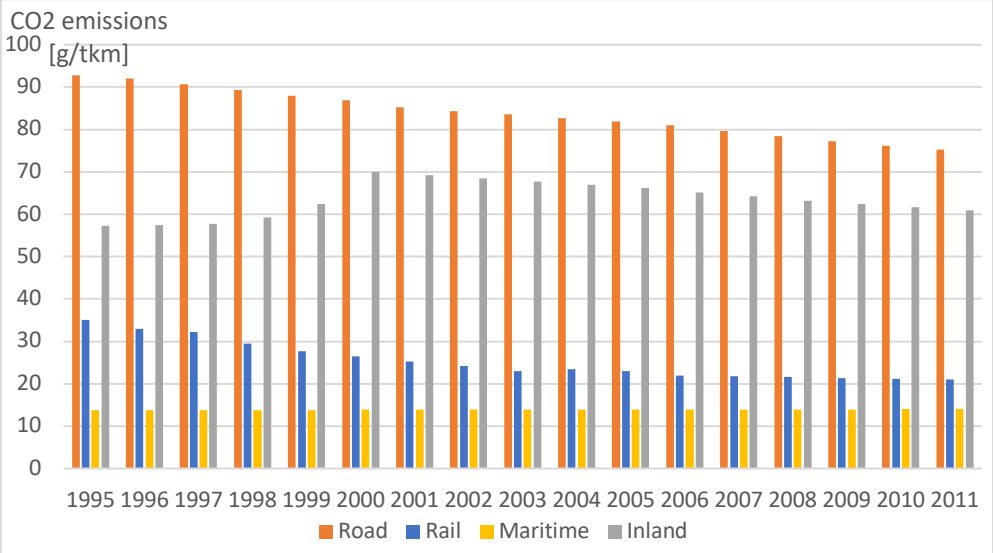
9. Appendix

The appendix first lists the included Figures, followed by the Tables and ends with the category "Other".

9.1. Figures

Figure A: EU CO_2 emission per g/tonne-km 1995 – 2011

Displayed to the respondents prior to the choice tasks in the SP survey



Source: EEA (EU) (2015)

Figure B: Auto-cluster tool Nvivo to cluster nodes according to coding similarity applied on the node code structure

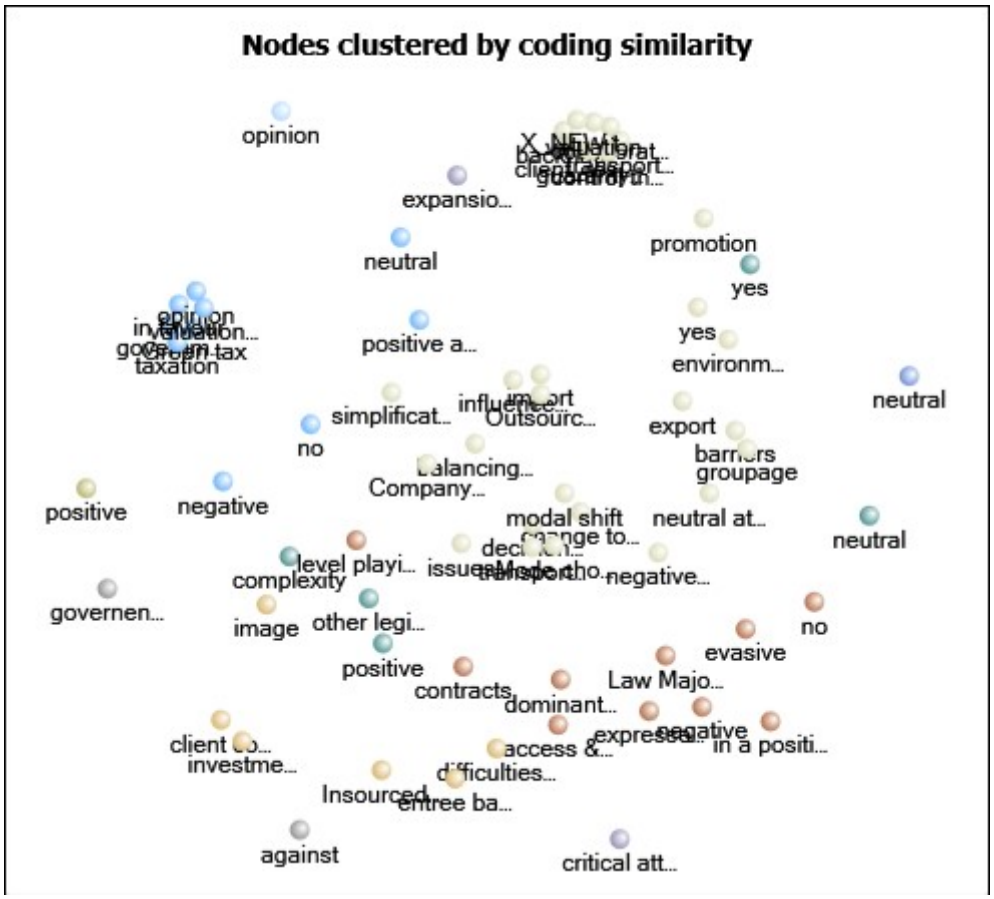
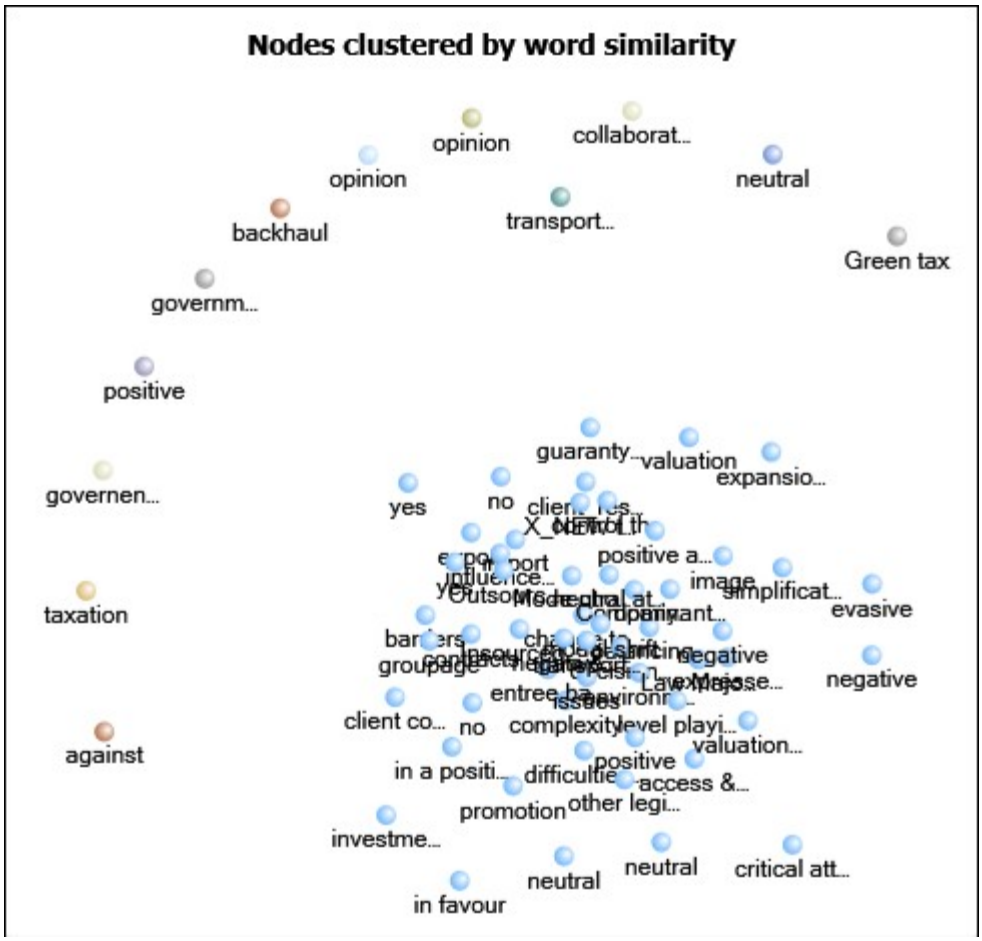


Figure C: Auto-cluster tool Nvivo to cluster nodes according to word similarity (word similarity set on: minimum 5 letters and 500 times occurrence level)



9.2 Tables

Table A: Loss and Damage calibration point table
Displayed to the respondents prior to the choice tasks in the SP survey

		frequency			
		Road	Rail	IWW	Sea
verlies of schade (promile)	0	75	18	37	35
	1	36	7	3	27
	2	47	2	2	6
	3	5	1	1	2
	4	1	0	6	15
	5	11	1	3	5
	10	6	2	1	5
	15	1	0	0	0
	20	3	0	0	2
	25	1	0	0	1
	30	3	0	0	1
	50	2	1	0	2

Source: VOT study de Jong et al. (2004)

Table B: Ngene design codes
B.a. Final design: Within-mode CTs

```
? Design Within end survey
Design
;alts = option1*, option2*, option3
;rows = 20
;block = 5
;eff = (mnl, d)


;model:
U(option1) = Btc[-0.006] * TC[-0.25,-0.10,0,0.10,0.25] + Btt[-0.1564] * TT[-0.20,-0.10,0,0.20,0.35]  + Benv[-0.7126] * ENV[-0.5,-
0.25,0,0.25,0.5] /
U(option2) = Btc       * TC[-0.25,-0.10,0,0.10,0.25] + Btt       * TT[-0.20,-0.10,0,0.20,0.35]  + Benv       * ENV[-0.5,-0.25,0,0.25,0.5] /
U(option3) = Btc       * TC[-0.25,-0.10,0,0.10,0.25] + Btt       * TT[-0.20,-0.10,0,0.20,0.35]  + Benv       * ENV[-0.5,-0.25,0,0.25,0.5] $

? Bayesian d-efficient design: priors used from pilot (all-values)
? generic parameters, conventionally in within
? unlabeled SE with 3 options, 3 attributes each with 5 levels
? attributes:
   ? cost -25% -10% REF +10% +25% (pivoted: done in excel with reference value provided by interviewee)
   ? usual transport time -20% -10% REF +20% +35% (pivoted: done in excel with reference value provided by interviewee)
   ? GHG -50% -25% 0% +25% +50% (absolute) (will be applied in excel with an absolute value for GHG per tonne-km resulting in absolute
values)
```

B.b. Final design: Between-mode CTs

```
? Design Between end survey
Design
;alts = Road, Rail, IWW, SSS
;rows = 40
;block = 5
;eff = (mnl, d)
;model:
U(Road) = Btc[-0.0076] * TC[-0.25,-0.10,0,0.10,0.25]   + Btt[-0.0003] * TT[-0.20,-0.10,0,0.20,0.35] + Bld[-1.1226] *
LD[0.0002,0.005,0.02,0.05,0.08]  + Benv[-0.7126]  * ENV[-0.5,-0.25,0,0.25,0.50]  + Brl[3.9548] * RL[0.98,0.90,0.85,0.80,0.75]     /
U(Rail) = Btc        * TC[-0.25,-0.10,0,0.10,0.25]   + Btt        * TT[-0.20,-0.10,0,0.20,0.35] + Bld        * LD[0.0002,0.005,0.02,0.05,0.08]  + Benv
* ENV[-0.5,-0.25,0,0.25,0.50]  + Brl        * RL[0.98,0.90,0.85,0.80,0.75]     /
U(IWW)  = Btc        * TC[-0.25,-0.10,0,0.10,0.25]   + Btt        * TT[-0.20,-0.10,0,0.20,0.35] + Bld        * LD[0.0002,0.005,0.02,0.05,0.08]  +
Benv        * ENV[-0.5,-0.25,0,0.25,0.50]  + Brl        * RL[0.98,0.90,0.85,0.80,0.75]     /
U(SSS)  = Btc        * TC[-0.25,-0.10,0,0.10,0.25]   + Btt        * TT[-0.20,-0.10,0,0.20,0.35] + Bld        * LD[0.0002,0.005,0.02,0.05,0.08]  + Benv
* ENV[-0.5,-0.25,0,0.25,0.50]  + Brl        * RL[0.98,0.90,0.85,0.80,0.75]
$
? Priors values from pilot used (between-all), except for ENV: prior value within (all) used as MNL model result not of expected sign
? Attributes:
?      TC and TT pivoted (applied in excel on values provided by interviewee)
?      ENV pivoted on absolute value expressed in tonnes-km
?      LD: absolute percentage: total percentage of cargo for typical transport lost or damaged
?      REL: absolute percentage arriving on time
? Design kept on MNL because of uncertain nature of size of the sample
```

Table C: MNL model: within-mode pilot data (to derive priors of d-efficient design SP)

```
LL:  -91.39194
Estimates:
         est     se trat_0  trat_1  robse robtrat_0 robtrat_1
asc1  0.2735 0.2697   1.01   -2.69 0.2237      1.22     -3.25
asc2  0.0203 0.2837   0.07   -3.45 0.2283      0.09     -4.29
tc   -0.0060 0.0031  -1.97 -327.83 0.0019     -3.13   -521.50
tt   -0.1564 0.0480  -3.26  -24.07 0.0803     -1.95    -14.40
env  -0.7126 0.3202  -2.23   -5.35 0.3646     -1.95     -4.70
```

Table D: MNL model: between-mode pilot data (to derive priors of d-efficient design SP)

```
LL:  -125.8257
Estimates:
         est     se trat_0  trat_1  robse robtrat_0 robtrat_1
asc1  1.0920 0.3701   2.95    0.25 1.0836      1.01      0.08
asc2  0.2216 0.4253   0.52   -1.83 1.1257      0.20     -0.69
asc3  0.8941 0.3935   2.27   -0.27 1.0961      0.82     -0.10
asc4 -0.5021 0.5198  -0.97   -2.89 1.2355     -0.41     -1.22
tc   -0.0076 0.0050  -1.51 -199.80 0.0020     -3.79   -500.73
tt   -0.0003 0.0575  -0.01  -17.41 0.0291     -0.01    -34.40
rl    3.9548 1.5617   2.53    1.89 2.6352      1.50      1.12
ld   -1.1226 0.6768  -1.66   -3.14 0.6242     -1.80     -3.40
env   0.0030 0.3416   0.01   -2.92 0.2783      0.01     -3.58
```

Table E: MNL model (all merged data): linear specification of attributes

	MNL		
	estimate	tratio	Rob. tratio
ASCs:			
asc1	-0.0162	-0.69	-0.91
asc2	-0.0213	-0.75	-0.99
road	0.3118	1.8	1.67
rail	0.0043	0.02	0.02
iww	0.1894	1.06	1.01
Attributes:			
transport time	-0.0125	-0.84	-0.8
transport cost	-0.0006	-0.89	-1.58
CO_2 emissions *DT*TN	-0.0079	-0.78	-1.1
loss and damage	-0.3888	-0.65	-0.27
reliability	6.5725	**8.46**	**5.17**
Scaling parameters:			
scale_base	1	NA	NA
scale_multiplier_WITH	9.3301	0.84 [a]	1.15 [a]
scale_multiplier_FINAL	1.2080	**2.8**[a]	**1.93** [a]
LL(0)	-744.32		
LL(final)	-668.78		
Estimated parameters	12		
AIC	1361.55		
BIC	1414.32		
Estimation time	00:00:21.93		

[a] t-ratio(1), robust t-ratio(1)

Table F: MMNL model: allowing for preference heterogeneity in TT, TC & ENV using Normal draws

	MMNL h(beta TC,TT,ENV)		
	estimate	tratio	Rob. tratio
ASCs:			
asc1	-0.1423	**-2.13**	-1.79
asc2	-0.1819	**-2.71**	**-2.99**
road	0.3612	1.91	1.58
rail	-0.003	-0.01	-0.01
iww	0.1766	0.91	0.81
Attributes:			
mu transport time	-0.0876	**-3.61**	**-3.78**
sigma transport time	0.0592	**2.65**	**3.48**
mu transport cost	-3.1614	**-6.64**	**-4.28**
sigma transport cost	1.2615	**3.55**	**3.42**
mu CO2 emissions	-0.0268	-1.28	**-2.12**
sigma CO2 emissions	0.0012	0.05	0.77
loss and damage	-1.0893	-1.64	-0.58
reliability	6.3644	**7.46**	**4.43**
Scaling parameters:			
WITH	1.1519	0.60	0.41
FINAL	0.3791	**-2.21**	***-1.95***
LL(choice model)	-446.8142		
Estimated parameters	15		
AIC	923.63		
BIC	989.58		

[a] t-ratio(1), robust t-ratio(1)

Table G: MMNL model: allowing for preference heterogeneity in TT, TC, ENV, REL, L&D using Normal draws

	MMNL h(beta TC,TT,ENV,RL,LD)		
	estimate	tratio	Rob. tratio
ASCs:			
asc1	-0.2888	**-1.98**	***-1.8***
asc2	-0.3956	**-2.72**	**-2.76**
road	0.4062	1.64	1.19
rail	-0.1507	-0.56	-0.39
iww	0.2438	1	0.82
Attributes:			
mu transport time	-0.2066	**-4.88**	**-5.25**
sigma transport time	-0.2016	**-3.57**	**-3.8**
mu transport cost	-7.3183	**-7.9**	**-8.16**
sigma transport cost	2.1254	**5.18**	**10.32**
mu CO2 emissions	-0.0327	-0.77	-1.48
sigma CO2 emissions	-0.0039	-0.08	-0.24
mu loss and damage	-44.014	**-5.62**	**-6.13**
mu reliability	8.6204	**4.65**	**4.7**
sigma reliability	11.6431	**4.41**	**3.42**
Scaling parameters:			
WITH	0.5216	**2.09**	1.6
FINAL	0.175	0.65	0.56
LL(choice model)	**-362.9083**		
Estimated parameters	17		
AIC	759.82		
BIC	834.56		

Table H: ICLV 2LV model with Choleski factor (neg Lognormal distributions, 200 Halton draws)

	Estimate	Std.err.	t.ratio(0)	Rob.t.ratio(0)
asc1	-0.1281	0.0676	-1.9	-1.24
asc2	-0.1783	0.0667	-2.67	-2.01
road	0.3244	0.2067	1.57	1.61
rail	-0.0443	0.2335	-0.19	-0.15
iww	0.052	0.2242	0.23	0.21
log_tt_mu	-2.855	0.2043	-13.98	-9.08
log_tc_mu	1.042	0.1813	5.75	2.62
log_env_mu	-6.212	13.208	-4.7	-2.28
ld	-1.234	0.7033	-1.75	-0.57
rl	6.780	0.8854	7.66	4.41
scale_base	1.000	NA	NA	NA
scale_multiplier_WITH	4.025	11.220	2.7[a]	1.2[a]
scale_multiplier_FINAL	1.071	0.2878	0.25[a]	0.14[a]
tau_envI	18.744	**NaN**	**NaN**	347.06
tau_envC	1.007	0.0496	20.29	11.03
tau_tcI	4.037	0.3045	13.26	4.35
tau_tcC	0.271	0.0263	10.32	4.14
tau_ttI	-5.087	0.4785	-10.63	-1.36
tau_ttC	-0.346	0.053	-6.53	-1.31
tau_green_rail_I	-19.56	24.763	-0.79	-0.7
tau_green_rail_C	-0.153	0.1758	-0.87	-0.77
tau_green_iww_I	7.706	25.667	3	3.46
tau_green_iww_C	0.501	0.1832	2.73	3.23
tau_green_sss_I	35.758	28.362	1.26	0.75
tau_green_sss_C	0.227	0.2029	1.12	0.67
sigma_green_tradeoff	0.632	0.1025	6.16	6.81
sigma_green_moral	0.909	0.1514	6	4.17
sigma_green_polagenda	0.012	0.0052	2.28	2.33
sigma_green_CFcons	0.899	0.1459	6.16	7.04
sigma_green_effroadpricing	1.213	0.2021	6	8.97
zeta_lv_green_tradeoff	0.576	0.127	4.53	3.37
zeta_lv_green_moral	0.337	0.1831	1.84	2.29
zeta_lv_green_polagenda	0.707	**NaN**	**NaN**	143.68
zeta_lv_green_CFcons	0.511	0.1808	2.83	3.6
zeta_lv_green_effroadpricing	-0.103	0.2496	-0.41	-0.43
sigma_green_employeesneg	0.898	0.1496	6	4.56
sigma_green_image	0.568	0.0948	6	7.27
sigma_green_highpotloss	0.556	0.0954	5.83	11.19
sigma_green_avoidtaxfine	0.362	0.0623	5.81	8.7

zeta_lv_green_employeesneg	0.001	0.0135	0.05	0.04
zeta_lv_green_image	-0.020	0.0086	-2.36	-2.83
zeta_lv_green_highpotloss	-0.010	0.0084	-1.16	-0.96
zeta_lv_green_avoidtaxfine	-0.031	0.0056	-5.62	-5
gamma_lv_I_female	-0.322	0.0097	-33.09	-43.32
gamma_lv_C_female	5.807	0.6909	8.4	5.14
factor_choleski	-13.892	0.133	-104.46	-28.03
LL(final)	-603.24			
LL(model)	-437.98			
AIC	1296.48			
BIC	1494.34			

[a] t-ratio(1), robust t-ratio(1)

9.3 "Other"

A. Attitudinal statements

Attitudinal part: individual level

Statements	Strongly disagree	Disagree	More disagree than agree	More agree than disagree	Agree	Strongly agree
Other problems than climate change are more urgent and important (e.g. the state of the economy, migration, security threats,…).	□	□	□	□	□	□
Environmental protection should be high on the policy agenda	□	□	□	□	□	□
Environmental protection measures to increase environmental welfare should be imposed, even if that means a cut in economic welfare	□	□	□	□	□	□
In my consumption I tend to look out for goods that have a lower carbon footprint	□	□	□	□	□	□
I am willing to pay for a higher personal energy bill to receive "greener" energy	□	□	□	□	□	□
I am morally obligated to act where I can in my personal consumption and activities to decrease my personal carbon footprint	□	□	□	□	□	□

In your opinion, to what extent are the following a problem:	Not a problem at all	Not a problem	Slightly not a problem	Slightly a problem	A problem	Major Problem
Congestion on the roads	□	□	□	□	□	□
Decrease of local air quality resulting from transport	□	□	□	□	□	□

In your opinion, how do you stand towards the policy idea of:	Strongly opposed	Opposed	Slightly opposed	Slightly supportive	Supportive	Strongly supportive
road pricing in an attempt to reduce GHGs coming from transport	□	□	□	□	□	□

GHG = Greenhouse gasses, such as CO_2, NO_2, …

And its effectiveness:	Strongly disagree	Disagree	More disagree than agree	More agree than disagree	Agree	Strongly agree
Road pricing is an effective way to achieve reductions of GHGs from transport	□	□	□	□	□	□

Attitudinal part: corporate level

Statements	Strongly disagree	Disagree	More disagree than agree	More agree than disagree	Agree	Strongly agree
Clients have chosen us because of our environmental friendly image.	□	□	□	□	□	□
We have better new hires because of our environmental friendly image	□	□	□	□	□	□
Some good employees could leave us because of our environmental less friendly image	□	□	□	□	□	□
There is activism against us in the local community because of our environmental image	□	□	□	□	□	□
Some high potentials did not want to work for us because of our environmental image	□	□	□	□	□	□
Our shareholders think living up to environmental standards pays part of their dividend	□	□	□	□	□	□
CSR is a well-embedded concept in our company's vision and mission statement	□	□	□	□	□	□
The existence of a green premium for companies in general is a fallacy	□	□	□	□	□	□

CSR = Corporate Social Responsibility

Green premium = premium that comes with making a company activity green

Environmental issues for my company are ….	Strongly disagree	Disagree	More disagree than agree	More agree than disagree	Agree	Strongly agree
Only important to avoid taxation and fines	□	□	□	□	□	□
Also important because we can get advantages (tax reductions, subsidies,…)	□	□	□	□	□	□
Important for our image	□	□	□	□	□	□
A priority to balance with others (production, profit,…)	□	□	□	□	□	□
The top priority above all other priorities	□	□	□	□	□	□

B. Interview Protocol

(The interview questions are translated directly from Dutch)

Interview Protocol:
- briefing: info, introduction researcher and research
- consent form
- turning on tape recorder
- QLi.Q1
- SP
- QLi.Q2/3/4
- turning off tape recorder
- attitudinal questionnaire (interviewer remains present, but does not look at interviewee filling in questionnaire: interviewer saves files to computer, clears out material, arranges university admin papers)

1) QLi.Q1: Could you describe the situation for incoming and outgoing typical transport flows to and from your company?
    a) Probe QLi.Q1: Is the transportation outsourced or is it part of the company?
        i) Probe questions if outsourced:
            (1) Which variables play a role for your company in the choice of a third party for the transport?
            (2) Does your company influence the choice of mode that is being used or is the decision left to the 3rd party?
            (3) Is there a difference between the ingoing and outgoing flows?
        ii) Probe questions if in-house:
            (1) Which variables play a role for your company in the mode choice?
            (2) Is there a difference between the ingoing and outgoing flows?

2) QLi.Q2 (reacting on comments made during the choice tasks after completion of all CTs)
    a) You made a comment in choice XX, could you elaborate on that comment?
    b) Did you have doubts with certain choices?
    c) Did you experience a difference between the unlabelled and labelled choice tasks?
        i) Probe question: Did you have a preference?
    d) Where you aware that you made specific type of choices during the choice tasks?

3) QLi.Q3: Was the setting of the choice experiment representative to your decision-making in practice?
    a) Probe question: Did you find that your preferences could be expressed during the experiment?

4) QLi.Q4: In your opinion, what are “trigger points” to attain a modal shift towards more sustainable modes in the Port of Ghent region?