SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

SPSD II

ASSESSMENT OF QUALITY DIFFERENCES BETWEEN FREIGHT TRANSPORT MODES

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GENERAL ISSUES

AGRO-FOOD

ENERGY

PART 1

SUSTAINABLE PRODUCTION AND CONSUMPTION PATTERNS — TRANSPORT

SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY
(SPSD II)

Part 1:

Sustainable production and consumption patterns

FINAL REPORT

ASSESSMENT OF QUALITY DIFFERENCES BETWEEN FREIGHT TRANSPORT MODES

CP/36

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1. Introduction : Context, objectives and methodology

The strong development of freight transports, particularly by trucking, is the source of important negative externalities: congestion, pollution, accidents, etc. A partial solution to these problems could be found in a policy of modal shift towards rail and inland waterways transports as well as towards inter-modal transport solutions. This policy is supported by various European authorities. However, information on the factors that affect modal shares is rather incomplete and mostly circumstantial. Most modelling approaches only include cost and time of transport as determining variables, whereas many actors involved in transportation insist that qualitative service factors also play an important role. This research endeavours to integrate qualitative factors like reliability, safety, information, flexibility of response, damages, etc. into a global analysis of the factors that affect the choices of freight transport means and modes.

The usual approaches based on published data are not feasible for studying qualitative factors. Relevant data should relate to factors taken into account by individual firms in their decision making; they are not published. Moreover, each firm and industry is characterised by specific circumstances that affect their choices. Hence, this research had to start with a survey of transport decision makers. This survey, which was completed at the beginning of 2004, aimed at covering all the factors relevant for decision making: observe the actual choices which are made in different industrial circumstances (revealed preference approach), but also question the decision makers about the choices they would make if some of the decision parameters were changed (stated preference approach). Given the time framework of the research program and the complexity of the problem, this survey was restricted to Belgian enterprises. Nevertheless, the international characters of Belgian economic transport activities provide a wide enough scope of enquiry. The modes that are the main objects of the survey are the road, the rail, the waterways, short-sea shipping and their multimodal combinations.

The research program started with a thorough review of the literature, which allowed us to design a questionnaire for interviewing freight transport managers. The interviewing process took a lot of time considering that many firms were reluctant to accept interviews and many delays were imposed to us. During the last year and a half of the contract, we applied several methodologies to the gathered data: : the usual econometric analyses based on a variety of logistic-type models, conjoint analysis, some models of multi-criteria analysis, neural network analysis, and frontiers analysis. The four first types of modelling aim at identifying the decision makers preference functions among transport solutions, whereas frontier analysis aims at exploring the nature of the transport services market. Several efforts were made to build up in-depth case studies, but we failed in those endeavours because of lack of appropriate data or the refusal to provide them. This is regrettable since case studies would have explored in more details the role of quality attributes in decision making by a particular firm.

During the year 2004 and the six months extending the contract until end of June 2005, most of above quantitative analyses were finalised and their results set up in several papers submitted for publication to international scientific journals. Their contents are reviewed in the following sections of this report. It is likely though that some additional results will be obtained in the coming months, as several members of the consortium will still be involved in that line of research.

2. Report on activities

Task A: This task, on the review of the theoretical and empirical literature, was substantially completed during the years 2002 and 2003. To some extent, it was continued until the end of the contract according to the new problems and the new publications arising. That was particularly the case with respect to some specific econometric techniques that we wished to apply. The relevant literature for our research project is discussed in the several papers containing our results.

Task B: Much work was devoted to the development of case studies by the University of Gent team. Unhappily, in several cases, the work started in a firm did not lead to any interesting outcome because of insufficient data and/or the firms' unwillingness to provide so-called confidential information. Until the end, the Gent team hoped to be able to work out one full-fledged case. A last attempt eventually failed.

Task C: After a few experimental interviews, and comments made by the assessing committee, a final questionnaire was set-up, somewhat shortened and simplified. The final version, in its Dutch and French versions, is attached in annex to this report (Annex 2.D and Annex 2.F).

Much time has been spent on the review of different types of econometric models available in the literature. Experimental estimations with different models were made on a small set of individual observations, which provided contrasting results. A paper comparing conditional 'logit', conjoint and multi-criteria analyses summarizes the results of those experiments on individual preference orders. Additional results on the same set of data were recently obtained by the UCL team using the neural network approach. It is planned to integrate them in the former paper in view of publication.

Task D: The shippers' survey was completed during the first few months of 2004. In effect, the survey work turned out to be much more arduous than anticipated. Actually, altogether we contacted 572 firms, of which 126 of them accepted an interview after some correspondence and telephone conversation.

Task E: The rough data coming from the interviews were then checked up and corrected, if needed, using external information and further contact with the interviewees. Indeed, some gaps in the data were filled in by additional questioning of the shippers, outside sources (like maps and distances on geographic webs), comparisons of results obtained from different shippers, and econometric techniques. In the end 113 of these interviews were complete enough to provide useful information. They were included in the final sample to analyze. Then, several preliminary papers were amended and completed. Some of them were presented at national and international conferences. Furthermore, additional final papers were written on the basis of the full available data set. All these papers are reviewed in the following sections of the report.

Task F: The cooperation within the consortium was quite satisfactory with much exchange of information. That was particularly important for the building of the data bank and a good understanding of the precise information to be introduced in it. This is not to say that it was not an arduous task to make sure that everyone was proceeding in the same defined and agreed upon way. The coordination was made through a number of working meetings held during the year, as well as by the writing of working notes. Detailed information about these activities can be found in the set of administrative reports written by each research team.

3. Models, papers and reports

3.1 Reports by the UCL team

3.1.1 A Multi-criteria methodology for stated preferences among freight transport alternatives

by M. Beuthe, Ch. Bouffioux, J. De Maeyer, G.Santamaria, M. Vandresse and F. Witlox

This is a collective paper discussing the survey methodology and providing some experimental estimates of individual preferences with the multicriteria UTA methodology. A more complete description can be found in 3.4.1, and in Annex-FUCAM-1-05. It has been published in A. Reggiani and L. Schintler (ed.), Methods and models in transport and telecommunications: Cross-Atlantic perspectives, Springer-Verlag, Berlin, 2005.

3.1.2 An empirical measure of market imperfection

by M. Mouchart and M. Vandresse (July 2005)

This paper provides the theoretical underpinning of frontier analysis applied on the observed transport flows data obtained in the survey. Starting from the idea that transport markets are characterized by heterogeneities of provided services and firms, it assumes that agents involved in these markets typically bargain simultaneously on a price and service attributes basis rather than on a price and quantity basis given the definition of the service levels. The importance of service attributes and heterogeneity naturally leads to concerns of market imperfection and relative bargaining powers in negotiating prices. Given the role played by the service attributes, these concepts should be better analyzed in terms of the joint distribution of price and service attributes rather than of the price and quantity given the levels of attributes.

In order to measure market imperfections, two bid functions are defined: the demand bid function that corresponds to the maximum that shippers would be ready to pay for transport service, and the supply bid function that corresponds to the minimum price the carriers would be ready to accept. In perfect competition these two functions would coincide; in imperfect competition the two functions are distant from each other. This feature allows to develop a measure of imperfection based on the ‘distance’ between the two functions, as well as measures of relative bargaining powers based on the ‘distances’ between observed contract prices and the maximum and minimum prices obtained on the bid functions. Frontier econometric analysis allows the estimation of these bid functions taking into account all the service attributes.

The paper provides a formal treatment of these ideas, explains the frontier analysis methodology, and, proposes an econometric approach for estimating the supply and demand bid functions taking into account the qualitative attributes. The conclusions underline that, whereas this data analysis approach does not provide a precise economic model of market imperfection, it permits to give at least a rough estimation of the amount of imperfection and of the (as)symmetry position of supply and demand in that imperfection. A full-fledged empirical analysis is presented in the paper reviewed in the following section 3.1.2.

In its preliminary version, the paper was presented at the Journée de microéconomie appliquée à Lille, as well as at the Conference WCTR 2004 in Istanbul. Its final version is given in Annex-UCL-1-05-F.

3.1.3 Bargaining powers and market segmentation in freight transport

by M.Mouchart and M. Vandresse (April 2005)

This paper is a full-fledged and complete empirical frontier analysis of the survey data following the lines of the previous paper. Starting with a brief reminder of the theoretical and empirical concepts, it then analyzes each of the transport contracts in the survey with respect to its position in terms of the market imperfection and its relative bargaining powers. This is done through several steps, first making an estimation of bid functions, then, examining the position of each contract with respect to the bid functions, the distribution of the results, and the role played by each attribute. The results suggest that freight transport in Belgium is dominated by the demand side.

A sensitivity analysis of the results obtained when excluding a particular attribute leads to the conclusion that no service attribute plays a significant role in the bargaining power, but that the latter is mainly related to the contract price. It cannot be excluded that some other (not observed) attributes would better explain the bargaining power.

The paper then proceeds to an examination of different market segments and specific data (outliers) that may influence the overall results. First, it appeared that excluding from the sample the rather few non-road observations did not result in much different results. This would suggest that agents would not be willing to pay for the mode of transport itself, but for its attributes. Secondly, observations corresponding to retail trade and to dangerous goods were excluded from the sample as they had outlying prices. This exclusion induced a substantial decrease of market imperfection as well as demand bargaining power. Thirdly, the observations lying on the two bid functions were withdrawn from the sample, as it could be suspected that they corresponded to particular types of goods. Again, this led to a decrease of market imperfection and better balanced bargaining powers.

The reader will find the paper in Annex-UCL-2-05-F.

3.1.4 Experiments in neural modelling of preference data

by C. Krier, M. Mouchart and A. Oulhaj (May 2005)

This paper builds upon a previous analysis by G. Santamaria, M. Mouchart and A. Oulhaj, which sets the concepts and methodology of a neural network approach applied to rank-ordered preference data. Here, two problems are analyzed.

The first problem is to define a relevant loss function to be iteratively minimised by the neuronal model. In this case, one should try to estimate the additive utility function that is able to reproduce as closely as possible the discrete ranking of transport alternatives as stated by the interviewed transport managers. However, a loss function in terms of discrete ranks is not continuously differentiable. This difficulty can be resolved by comparing the stated ranking to an appropriately defined utility function which covers the same domain as the ranking, i.e. 1 to 25. Alternatively, one may adopt a heuristics, the “Pocket algorithm”, which allows the minimization of a non-continuous loss function. In this paper, the latter is set either as a function of the squared error between the estimated utility and the stated rank, or as a function of the correlation coefficient of Kendall. The paper sets up the algorithms to be used in each case.

The first approach applied to individual data does not lead to convincing results as the transformed continuous loss function does not approximate correctly the discrete function in some cases, so that the model’s performance, i.e. the fit between the estimated and stated orders of preference, is weak. Moreover, the coefficients’ signs tend to be incorrect. The results obtained by the second approach are more satisfactory, even though some coefficients obtain incorrect signs. The performance of the model is not far behind the results produced by the UTA and quasi-UTA multi-criteria methodology, and superior to results obtained by the more classical logit models (see Annex-FUCAM-1-05 and Annex-FUCAM-3-05). This should not come as a surprise, since both the multi-criteria models and the present neural model introduce non-linear utility functions.

The second problem is to define a methodology that would allow the testing of two hypotheses: whether the model's parameters are common to all observations, so that the variability of the preferences between firms is due to unobservable firm-specific factors, or whether the parameters are specific to each firm. The paper proposes an approach for analyzing this question, which will be eventually applied in the near future.

The full paper can be found in Annex-UCL-3-05-F.

3.2 Reports by the U.A. team

3.2.1 A Multi-criteria methodology for stated preferences among freight transport alternatives

by M. Beuthe, Ch. Bouffioux, J. De Maeyer, G.Santamaria, M. Vandresse and F. Witlox

This is a collective paper discussing the survey methodology and providing some experimental estimates of individual preferences with the multicriteria UTA methodology. A more complete description can be found in 3.4.1, and in Annex-FUCAM-1-05. It has been published in A. Reggiani and L. Schintler (ed.), Methods and models in transport and telecommunications: Cross-Atlantic perspectives, Springer-Verlag, Berlin, 2005.

3.2.2 Impact of quality indicators on freight transport: An aggregate analysis

by H. Meersman, T. Pauwels and E. Van de Voorde

This paper is an aggregate econometric analysis of the rank-ordered preference data using the 'probit' model framework. The model, which assumes a normal distribution of errors, presents an advantage with respect to the logit model in that it does not impose the condition of independence of irrelevant alternative, and does not assume homoscedasticity. As will be seen again below (in 3.4.3) rank-ordered preference data must be handled in a special way in order to be used in econometric analysis. First, the selected probit model version is based on the general ordered-response framework that aims at estimating utility intervals corresponding to the successive ranks. Second, it focuses on the ranking of the status quo alternative, the one presently used by the firm, for which are computed the frequencies of its various preference rankings over the sample. These frequencies are taken as the dependent variables of the model. Additional variables (distance, annual tonnage, value added of the firm) are introduced next to the attributes values as independent variables. The attributes variables, except Cost, are all multiplied by the value of the goods in order to better reflect the role played by these variables in the logistic management of the firm.

The results of a first global aggregate analysis seem to indicate that Flexibility and transport Time are the more significant factors in decision making; the levels of significance of the other variables are poor.

Another aggregate analysis was made in two steps: first separating transport alternatives in two subgroups of preference on the basis of the choices made by the transport managers, second, analyzing the ranking frequencies within each subgroup. The first step analysis indicated that Flexibility and the firms' added value played a significant role in this context. In the second step, the preference computation over the most preferred subgroup shows that Cost, Time and annual tonnage play a significant role, whereas the analysis of the second preference subgroup pick up the significant role of added value and of every attribute with the exception, surprisingly, of the Cost.

These preliminary results provided an opportunity to compute the equivalent monetary values of each attribute. Considering the values provided by the four estimations, it turned out that time was valued between 0.7 € per ton per hour for low valued goods and 8.3 € for high valued goods. The values obtained by the global approach and for the second group were on the low side. Flexibility obtained values between 20.5 and 424 € per % point of variation. Reliability was valued between 52 and 495 € per % point; Frequency was between 129 and 776 €; and finally, Damages and losses were valued between 32 and 50 €. These results are indicative of the firms' heterogeneity of situation. More detailed research will be necessary to give an appropriate interpretation to such results.

3.2.3 La qualité des services de transport de merchandises: une analyse aggrégée des orders de preferences declarés

by Ch. Bouffioux, M. Beuthe and T. Pauwels

A description of the paper can be found under 3.4.1.

3.2.4 Stated preferences: Friedman test

by H. Meersman, T. Pauwels and E Van de Voorde

This is a paper still in progress, which is systematically testing whether the preference orders are identical or independent, and whether they could be grouped according to some categories.

3.3 Reports by the U. of Gent team

3.3.1 A Multi-criteria methodology for stated preferences among freight transport alternatives

by M. Beuthe, Ch. Bouffioux, J. De Maeyer, G. Santamaria, M. Vandresse and F. Witlox

This is a collective paper discussing the survey methodology and providing some experimental estimates of individual preferences with the multicriteria UTA methodology. A more complete description can be found in 3.4.1, and in Annex-FUCAM-1-05. It has been published in A. Reggiani and L. Schintler (ed.), Methods and models in transport and telecommunications: Cross-Atlantic perspectives, Springer-Verlag, Berlin, 2005.

3.3.2 Determining the monetary value of quality attributes in freight transportation using a stated preference approach

by F. Witlox and E. Vandaele

This paper provides a general overview of much of the approach chosen by the consortium to analyze and measure the role played by qualitative attributes in transport decision making. It is a follow-up version of the above collective paper 3.3.1. It states the problem and its importance, defines the qualitative attributes that are the most important (Frequency, Time, Reliability, Flexibility, Loss and damages), describes the survey and its questionnaire, and explains the stated preference experiment submitted to the interviewed transport managers. An illustration is given of the type of output that can be obtained from the survey data by using a multi-criteria technique (UTA). It shows how equivalent monetary values can be computed for the qualitative attributes, willingness to pay for a better service as well as willingness to accept compensation in case the service quality is decreased.

The paper has been published in Transportation Planning and Technology, Vol. 28 (2), 2005. It is given in Annex-Gent-1-05.

3.3.3 Kwaliteitsattributen in het goederenvervoer gemeten: een "stated preference" benadering

by E. Vandaele and F. Witlox

This paper is an adapted Dutch version of the above paper, which was written for and published in 'Tijdschrift Vervoerswetenschap", jaargang 40, nummer 7.

The paper is given in Annex-Gent-2-05.

3.3.4 One good turn deserves another. A shipper's willingness to pay for quality in freight transportation

by E. Vandaele, F. Witlox and G. Verleye

3.3.5 The use of correlation analysis to explain the monetary value of quality attributes of transportation

by E. Vandaele, F. Witlox and G. Verleye

Those two papers report a full-fledged statistical analysis of the survey's data: some of the firms' data and particularly the data of the typical flows that are relevant for the stated preference experiment, but also the estimates of willingness to pay (or to accept compensation), i.e. equivalent monetary values, obtained from the stated preference experiment. This analysis is aiming at testing a number of a priori hypotheses concerning the distributions and the inter-relations between variables.

It turned out that no distribution could be characterized as normal, what could be expected given the heterogeneity of the sample and the presence of categorical variables. Next, it was found that there were rather weak or no correlation between levels of qualitative variables, with the exception of Flexibility and Reliability. Generally, the correlations between the willingness to pay (or to accept compensation) of the different qualitative attributes are higher but exceptionally above .5. The highest correlations are between the monetary values of Flexibility and Frequency, and between the monetary values of Time and Frequency. Time and Distance naturally were highly correlated.

The non-parametric Kruskal-Wallis test also is applied to the data. It allows to test whether the means of two or more sub-groups are different. This test reveals that:

- The firms' type of activity (factory, wholesale, warehousing or other) has an influence on the qualitative attributes monetary values. For example, the value of time is lower for the firms in wholesale trading, but they are ready to pay more for a higher reliability. Warehousing firms are not ready to pay as much as other firms for an improved frequency or a reduced time of transportation.

- Firms shipping higher value goods are willing to pay more for a higher frequency. The price they pay is higher, and the levels of flexibility and reliability they obtain is also higher.
- Whether or not a company works in just-in-time does not affect much the values of the quality attributes.
- Incoterms of the shipping do not affect much the values of the attributes.
- The mode of transportation does matter: transport time is shorter by road; price and flexibility are lower for transports using rail or waterways; reliability is lower for combined rail. Firms using road transport give more value to time.

This is still work in progress. Parts of these two working papers were presented at the Vervoerslogistieke Werkdagen in Hoeven (NL) in November and at the ETC Conference in Strasbourg in October.

3.3.5, The importance of quality attributes of transportation in the total logistic costs

by Vandaele E., M. Beuthe and F. Witlox

This is a variant around the theme of paper 3.4.2 with the same authors; it was presented at the Delft's Colloquium Vervoersplanologisch Speurwerk 2003, No pay, no queue? It is published in Oplossingen voor bereikbaarheidsproblemen in steden – Deel 3, Delft's Colloquium Vervoersplanologisch Speurwerk, blz. 923-942, 2003.

It can be found in Annex-Gent-3-04.

3.4 Reports by the FUCAM team

3.4.1 A Multi-criteria methodology for stated preferences among freight transport alternatives

by M. Beuthe, Ch. Bouffioux, J. De Maeyer, G.Santamaria, M. Vandresse and F. Witlox

This paper is a revised version of an earlier one that explains the first steps of our research plan on transport modes and means' quality differences: the context of the problem, the definition of the quality differences, the survey's methodology, our questionnaire, and the design of the stated preferences experiment based on a fractional factorial design of 25 transport alternatives that must be ranked in preference order by the interviewed transport managers. The paper also explains the use of the UTA and Quasi UTA non-linear multi-criteria models for handling rank-ordered preference data. As an illustration, the latter technique is applied on a small set of nine firms in different fields of activity. Also, it shows how the estimation of a non-linear utility function allows the derivation of equivalent money values both in terms of willingness to pay and willingness to accept compensation.

The paper has been published in A. Reggiani and L. Schintler (ed.), Methods and models in transport and telecommunications: Cross-Atlantic perspectives, Springer-Verlag, Berlin, 2005. It is given in Annex-FUCAM-1-05.

3.4.2 Total logistics cost and quality attributes of freight transportation

by M. Beuthe, E. Vandaele and F. Witlox

This is an attempt to provide a theoretical framework for linking the theory of "total logistics cost" and the evaluation of the role played by transport qualitative services. It analyzes the functional relationships between qualitative factors (Frequency, Time, Reliability, Flexibility and risk of losses and damages) and the various elements of the logistic cost: transport cost, handling costs, ordering cost, and inventory costs for the cycle stock, the in-transit inventory and the safety stock. A number of parameters are identified which could be estimated for any particular firm. These parameters are illustrated on the basis of a previous case-study developed by Vernimmen and Witlox. The next step is examining the optimal conditions of a minimum of logistics cost with respect to the shipment size, and the set of transport quality attributes. This leads to a new condition defining the 'optimal order quantity', but also to establish optimal relationships between the costs paid by the firm and the cost internal to the firm with respect to each qualitative attribute. They give a theoretical interpretation of the firms' willingness to pay for an attribute, and could provide an interesting point of comparison with estimates derived by other methods, like stated or revealed preference techniques.

The paper was presented at the Conference WCTR2004 in Istanbul (July) and is included in the Selected Proceedings of the Conference. It is given in Annex-FUCAM-2-05

3.4.3 A comparison of conjoint, multi-criteria and conditional logit analyses for rank-ordered data

by Ch. Bouffioux and M. Beuthe

This working paper reviews various econometric models that could be used for analyzing the individual firms' rank-ordered stated preference data: conjoint analysis, multi-criteria analysis, and conditional logit. For testing these methodologies, they were applied to a set of nine firms with different profiles. Conjoint analysis was found to be consuming too many degrees of freedom. Hence, this approach was abandoned and a simple regression analysis of the ranks over the values taken by the attributes was made. In a more complex analysis, a monotone transformation of the rank was optimized in order to obtain a function better expressing the preferences of the decision makers. Multi-criteria analysis utility functions had already been computed with the UTA and Quasi-UTA models well documented in paper 3.4.1. Conditional logit analysis presents a particular computing difficulty with rank-ordered data. Indeed, in order to follow the model set by Beggs et al., it was necessary to handle the data in such a way that the choices made by the decision makers, i.e. the dependent variables, corresponded to a series of preferred choices with respect to a decreasing set of alternatives. Two versions of that model were used: the straightforward conditional logit version and the nested version which permits to introduce different distributions of errors for subgroups of data. This latter version was particularly relevant, since the transport managers were asked to rank the submitted transport alternatives in two steps: first the constitution of three preference subgroups, then a ranking of individual alternatives within each group. The comparison between the models was mainly made in terms of the Kendall coefficient of rank correlation.

The main conclusion of that exercise is that the multi-criteria methods that allow the computation of non-linear utility functions obtain the best ranking results. UTA provides the best results, but Quasi-UTA is not much inferior, whereas it does not use as many parameters. The hypothesis of different distributions allowed by the nested logit is not significantly verified, whereas the model's parameters do not come out as significant as in the simple conditional model. Another outcome is that the results vary very much from one firm to another, as the firms in the set have very different profiles. This suggests that, subsequent aggregate analyses will have to carefully proceed through different subgroups of data.

The paper is given in Annex-FUCAM-3-05. It was presented at the NECTAR-STELLA conference in Las Palmas, June 2005. A final version, incorporating some results of the above neural network analysis (3.1.3), is in preparation for publication in a transport scientific journal's special issue.

3.4.4 La qualité des services de transport de marchandises: une analyse aggrégée des ordres de préférence déclarés

by Ch. Bouffioux, M. Beuthe and T. Pauwels

From the aggregated data of the stated preferences survey this paper aims at estimating the relative importance and value for the freight shippers of the qualitative factors that characterize transport solutions: service frequency, transport time, reliability of delivery, caarier's flexibility and safety. Given that the survey elicited only orders of preference from the interviewed transport managers, the econometric technique relies on the conditional logit model adjusted by Beggs et al. (1981) for that type of data. It is applied to the global sample but also to the sub-samples classified according to distance categories, value and type of goods, modes, willingness to switch mode, and loading unit categories. Most of the linear utility functions coefficients estimated in this way are highly significant, with the exception of those of Frequency. The coefficients of the rail and inland waterway subgroups are also less significant, which can be the result of their smaller subgroups. This analysis shows that, whereas transport cost is the dominant factor in the choice of a transport solution, qualitative factors also play an important role, particularly transport time and reliability. Moreover, the results indicate that the factors' relative importance varies very much according to the categories of firms and transports. This suggests a strong heterogeneity of transport situations, as pointed out by the frontier analyses by M. Mouchart and M. Vandresse in paper 3.1.3. From the estimated utility function's coefficients specific to each subgroup, the paper derives the monetary equivalent value of each qualitative attribute. Again here, as a consequence, very different values are obtained. They are partly explained by the type of transport they refer to, which is shown by relating these values to the transport time, the distance and the shipment size. This outcome is quite coherent with the wide dispersion of results published in the literature, which, based on samples of different natures, obviously refer to very different transport situations.

The paper can be found in Annex-FUCAM-4-05

3.4.5 Analyzing freight transports' qualitative attributes from stated orders of preference

by M. Beuthe and Ch. Bouffioux

This paper is a continuation of the above 3.4.4 paper. It was motivated by a test, proposed by Ben-Akiva et al. (1992), which showed that the attributes' coefficients across subgroups in a set where not significantly different from each other, with the exception of the cost attribute. This result was entirely coherent with the observation by M. Mouchart and M. Vandresse in paper 3.1.3 that "no observed (qualitative) attribute seems to play a dominant role in the bargaining process". As a consequence, we were lead to re-estimate the utility functions, assuming that the qualitative attributes had a common coefficient across sub-groups and that only the cost attribute had coefficients specific to each sub-group. This strong restriction on the utility functions naturally lead to lower statistical performance in terms of the rank correlation coefficient of Kendall, but produced highly significant coefficients in all cases. The paper concludes with a comparison of the attributes' monetary values obtained from this estimation and some of the estimates published in the international literature, pointing out the wide spread of values which refer to different transport situations.

This paper can be found in Annex-FUCAM-5-05

Annexes

1. **Annex 2-D**: **FUCAM, RUG, UA, UCL**, Enquête over de kwaliteitscriteria bepalend by de keuze van de modus, finaal versie, January 2003.
2. **Annex 2-F: FUCAM, RUG, UA, UCL**, Questionnaire de préférence déclarée sur le rôle des attributs qualitatifs dans le choix d'un mode de transport de marchandises, Version finale, January 2003.
3. **Annex-UCL-1-05-F:** M. Mouchart and M. Vandresse, An empirical measure of market imperfection, July 2005.
4. **Annex-UCL-2-05-F:** M. Mouchart and M. Vandresse**,** Bargaining powers and market segmentation in freight transport, April 2005.
5. **Annex-UCL-3-05-F:** C. Krier, M. Mouchart, and A. Oulhaj, Experiments in Neural Modelling of preference data, May 2005.
6. **Annex-Gent-1-05**: F. Witlox and E. Vandaele, Determining the monetary value of quality attributes in freight transportation using a stated preference approach, Transportation Planning and Technology, Vol. 28 (2), 2005.
7. **Annex-Gent-2-05**: E. Vandaele and F. Witlox, Kwaliteitsattributen in het goederenvervoer gemeten: een "stated preference" benadering, Tijdschrift Vervoerswetenschap", jaargang 40, nummer 7. Also in C.J. Ruijgrok and R.H.J. Rodenburg (ed.), Bijdragen Vervoerslogistieke Werkdagen 2003 (Deel 2). Delft, Connekt, blz. 315-324, 2003.
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9. **Annex-FUCAM-1-05:** M. Beuthe, Ch. Bouffioux, J. De Maeyer, G.Santamaria, E. Vandaele, M. Vandresse and F. Witlox, A multicriteria analysis of stated preferences among freight transport alternatives, in L. Schintler and A. Reggiani (ed.), Methods and Models in Transport and Telecommunications: Cross-Atlantic Perspectives, Springer-Verlag, July 2005

10. Annex-FUCAM-2-05: M. Beuthe, E. Vandaele and F. Witlox, Total logistics cost and quality attributes of freight transportation, paper presented at the Conference WCTR2004 in Istanbul, and included in the Selected Proceedings (2005) of the conference.

11. Annex-FUCAM-3-05: Ch. Bouffioux and M. Beuthe**,** A comparison of conjoint, multi-criteria and conditional logit analyses for rank-ordered data, November 2004, presented at the NECTAR-STELLA conference in Las Palmas, June 2005.

12. Annex-FUCAM-4-05: Ch. Bouffioux, M. Beuthe and T. Pauwels, La qualité des services de transport de marchandises: une analyse aggrégée des ordres de préférence déclarés, May 2005.

13. Annex-FUCAM-5-05: M. Beuthe and Ch. Bouffioux, Analyzing freight transports' qualitative attributes from stated orders of preference, June 2005.

Working notes

In some cases, the following items are preliminary drafts of the final papers reviewed in the above sections, but they mainly relate to initial thoughts and discussions presented to the consortium, and to additional technical notes on data or techniques needed in the course of our researches. These working notes are not annexed to the present report, but many of them had been annexed to previous scientific reports and/or administrative reports.

Working notes in 2002

Beuthe M. (FUCAM), Working note on the techniques for assessing the relative importance and monetary values of transport attributes.

Beuthe M. **(FUCAM)**, Computation of money equivalent value with UTA.

Bouffioux Ch., J. De Mayer and B. Van Broeckhoven (FUCAM-UA-RUG), Justifications for the questions used in the questionnaire.

Bouffioux Ch. **(FUCAM)**, Conjoint analysis of stated preference in the marketing literature.

De Mayer J. **(UA)**, Segmentation of goods. .

De Mayer J and T. Pauwels (UA), Literature Review: quality of service for mode choice modelling for freight.

Santamaria G. (UCL), The artificial neural network in the discrete modal choice.

Van Broeckhoven B. (RUG.), Case study – Quality aspects of an intermodal terminal..

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Witlox F. and B. Van Broeckhoven (RUG), Quality attributes in Passenger transport as a basis for freight transport modelling? A review of literature.

Working notes in 2003

Beuthe M. (FUCAM), Total logistics cost and quality attributes of transportation.

De Maeyer J., Hilde Meersman and E. Van de Voorde (UA), Experiences with the Nlogit/Limdep software

Mouchart M. and A. Oulhaj (UCL), Neural networks for stated preference data.

Mouchart M. and M. Vandresse (UCL), A hedonic approach of the imperfect market of freight transport by frontier: theory and application.

Working notes in 2004

Bouffioux Ch. and M. Beuthe (FUCAM), Conjoint analysis versus multi-criteria analysis of rank-ordered data.

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Bouffioux Ch. (FUCAM), Sample distribution versus Belgian statistics.

Bouffioux Ch. (FUCAM), Missing data imputation.

Mouchart M. and M. Vandresse (UCL), Analysis of unit non-response.

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Vandaele E. and F. Witlox, Case study report

Vandaele E. and F. Witlox, Case study report (Enquête over the kwaliteitscriteria bepalend by de keuze van de modus).

Annex 2-D

Enquête over de kwaliteitscriteria bepalend bij de keuze van de modus

Deze vragenlijst werd gerealiseerd door een samenwerking tussen de Universiteiten van Antwerpen (UA-UFSIA), Bergen (Fucam), Gent (RUG) en Louvain-la-Neuve (UCL).

Deze vragenlijst behandelt enkel verzendingen van de vestiging zelf

A. Kenmerken van de vestiging

1. Vul volgende coördinaten van de vestiging in:

1. Naam van de vestiging : ______________________
2. Adres van de vestiging
(plaats van verzending) Straat, nr. : ______________________
Plaats, postcode : ______________________
3. Contactpersoon : ______________________
4. Telefoon : ______________________
5. Fax : ______________________
6. e-mail : ______________________
7. Sector (NaceBel code) : ______________________
8. Aantal werknemers : 2001 = ------ 2000 = ------ 1999 = -------
9. Zakencijfer in € : 2001 = ------ 2000 = ------ 1999 = -------

2. Activiteiten : Duid de meest passende omschrijving van uw vestiging aan:

1. o Fabriek of productie-atelier
2. o Groothandel
3. o Magazijn of logistiek platform
4. o Andere gelieve te preciseren ______________________

A. 1 Organisatie van het transport

3. Duid het gepaste vakje aan met betrekking tot de organisatie van het transport van uw verzendingen (voor elke vraag zijn meerdere antwoorden mogelijk) en geef het percentage aan dat hiermee overeenstemt:

	Klant	Verzender van de goederen		Door de verzender aangewezen dienstverlener		
		Vestiging	Groep of onderneming waartoe de vestiging behoort	Transport firma [A]	Forwarder/ Expediteur [B]	Logistiek dienstverlener [C]
Wie beslist er over de mogelijke transportopties en de kwaliteitscriteria bij het kiezen van de modus en de keuze van de partners ?	o .....%	o .....%	o .....%	o .....%	o .....%	o .....%
Wie doet de organisatie van het transport	o .....%	o .....%	o .....%	o .....%	o .....%	o .....%
Wie doet de uitvoering van het transport	o .....%	o .....%	o .....%	o .....%	o .....%	o .....%

A : Transportfirma: Deze dienstverlener beschikt over voertuigen (transporteur, rederij of spoorwegmaatschappij) en gaat tegen betaling vrachten vervoeren.

B : Forwarder/Expediteur: Deze tussenpersoon organiseert het transport en stelt de contracten op (douane, verzekeringen,…). Mogelijkerwijze beslist men hier over de transportmodus en de te volgen route. De forwarder/expediteur selecteert de transportfirma, onderhandelt over contracten aangaande transport en opslag en verzorgt de communicatie tussen de verzender en de transportfirma (instructies, informatie,…).

C : Logistiek dienstverlener: Een logistiek dienstverlener of provider biedt een logistieke totaal-oplossing aan gebruik makend van eigen vervoersmiddelen. Het gaat over opslag, verpakken, transport en distributie, opvolgen van bestellingen,… in opdracht van een onderneming of groep ondernemingen.

4. Is de beslissing om het transport zelf te organiseren respectievelijk out te sourcen in de eerste plaats gebaseerd op de kost (u kiest de goedkoopste oplossing) of gaat het ook om kwalitatieve kenmerken? Gelieve de elementen aan te kruisen die u beïnvloeden bij uw transportbeslissingen (meerdere antwoorden zijn mogelijk).

1. o Betaalde kost of prijs van het transport; inclusief laden en lossen (out of pocket kost)

2. o Kwalitatieve kenmerken
   - o **Betrouwbaarheid** van de levertijden: aantal keren dat de verzending binnen de vooropgestelde termijn arriveert (%)
   - o **Tijdsduur** van het transport van deur tot deur; inclusief laden en lossen
   - o **Frequentie** van de aangeboden dienst
   - o **Track and Trace**: elektronische opvolging van de verzending
   - o **Flexibiliteit**: het snel reageren op onverwachte of niet-geprogrammeerde aanvragen
   - o Schade, diefstal en ongevallen
   - o Andere: Gelieve te preciseren ....

5. Beschikt u over rollend materieel voor het transport van uw verzendingen ? (in eigendom, geleasd of gehuurd op lange termijn)

o Neen	
o Ja	o Wagenpark # Bestelwagens ⇒ laadvermogen < 1 ton # Solo-vrachtwagens ⇒ 10 ton < laadvermogen < 23 ton # Trekker/oplegger ⇒ 23 ton < laadvermogen
	o Spoormaterieel # Locomotieven # Wagons
	o Schepen # Schepen # Duwers # Duwbakken

	o Transporteenheden o Oplegger o Mobiele laadeenheid o Container o Mega-railer

6. Beschrijf uw toegangsmogelijkheden tot de transportinfrastructuur? Heeft u een directe toegang (*) tot de verschillende transportmodi? En gebruikt u deze voor uw verzendingen?

(*) Onder *"directe toegang"* verstaan we dat er geen extern voortransport nodig is om de infrastructuur te bereiken.

	Directe toegang	Gebruikt u deze toegang?	Indien geen directe toegang : Op hoeveel km ligt de dichtste toegangs-mogelijkheid?	Gebruikt u deze toegang?
Autosnelweg	Ja o - Neen o	Ja o - Neen o	……	Ja o - Neen o
Spoorwegen	Ja o - Neen o	Ja o - Neen o	……	Ja o - Neen o
Binnenvaart	Ja o - Neen o	Ja o - Neen o	……	Ja o - Neen o
Zeehaven	Ja o - Neen o	Ja o - Neen o	……	Ja o - Neen o
Vrachtluchthaven	Ja o - Neen o	Ja o - Neen o	……	Ja o - Neen o

A. 2 Kenmerken van transport

7. Hoeveel bedraagt het budget voor transport in uw vestiging met betrekking tot de uitgaande stromen (schatting voor het jaar 2001 en de kosten van aanvoer en intern transport buiten beschouwing gelaten) ?

#Absolute waarde	€ ………………………
#Als percentage van de totale productiekosten	%

8. In de eerste tabel vragen we om de ruimtelijke spreiding van uw omzet aan te geven door de percentages per land/regio aan te vullen. In de tweede tabel kan u het aantal klanten en de omzet opdelen naar de afgelegde afstand (enkel) tussen uw vestiging en de bestemmeling (cijfers van 2001).

Totaal aantal klanten:

Bestemmingsregio	% van de omzet
1. Benelux	_ _ _ _ _ _ _ _ _ %
2. Frankrijk	_ _ _ _ _ _ _ _ _ %
3. Italië	_ _ _ _ _ _ _ _ _ %
4. Zwitserland	_ _ _ _ _ _ _ _ _ %
5. Spanje, Portugal	_ _ _ _ _ _ _ _ _ %
6. Duitsland	_ _ _ _ _ _ _ _ _ %
7. Slovakije, Tsjechië	_ _ _ _ _ _ _ _ _ %
8. Polen	_ _ _ _ _ _ _ _ _ %
9. Oostenrijk, Slovenië, Hongarije	_ _ _ _ _ _ _ _ _ %
10. Estland, Letland, Litouwen	_ _ _ _ _ _ _ _ _ %
11. Croatië, Bosnië-Herzegovina, Joegoslavië	_ _ _ _ _ _ _ _ _ %
12. Ukraine, Witrusland, Rusland	_ _ _ _ _ _ _ _ _ %
13. Scandinavië, Denemarken	_ _ _ _ _ _ _ _ _ %
14. Verenigd-Koninkrijk, Ierland	_ _ _ _ _ _ _ _ _ %
15. Griekenland, Turkije, Bulgarije, Roemenië, Albanië	_ _ _ _ _ _ _ _ _ %
16. Andere	_ _ _ _ _ _ _ _ _ %

	Aantal klanten (%)	*% van de omzet*
1. < 250 Km	o ……	o …… %
2. 250 – 500 Km	o ……	o …… %
3. 500 – 1500 Km	o ……	o …… %
4. > 1500 Km	o ……	o …… %

9. Kan u het jaarlijks vervoerde tonnage (uitgaande stroom) procentueel opdelen naar de gebruikte modus (unimodaal of multimodaal & cijfers van 2001)? Wanneer u unimodaal te werk gaat, betekent dit dat het hele traject door deze modus wordt afgelegd.

Modi	Uitgaande stroom	Uitsplitsing van uw multimodaal vervoer	
1. o Wegvervoer	… %	8.1 Weg – Spoor	… %
2. o Spoorwegen	… %	8.2 Weg – Binnenvaart	… %
3. o Binnenvaart	… %	8.3 Weg – SSS	… %
4. o Maritiem	… %	8.4 Spoor – Binnenvaart	… %
5. o Short Sea Shipping (SSS)	… %	8.5 Spoor – SSS	… %
6. o Luchtvaart	… %	8.6 Binnenvaart – Maritiem	… %
7. o Pijpleidingen	… %	8.7 Andere	
8. o Multimodaal	… %	___ - ___	… %
		8.8 Trimodaal	
		___ - ___ - ___	… %
	100 %		100 %

10. Wat is de gemiddelde commerciële waarde van uw goederen die de vestiging verlaten uitgedrukt in €/kg (value/weight).

o	Waarde < € **6** / kg
o	€ **6** / kg < waarde < € **35** / kg
o	€ **35** / kg < waarde

11. Welke goederencategorieën worden er vanuit uw vestiging verzonden?

- General Cargo

- Containers

o Gekoelde en niet gevaarlijk stoffen
o Gekoelde en gevaarlijke stoffen
o Niet gekoelde en niet gevaarlijke stoffen
o Niet gekoelde en gevaarlijke stoffen

- Niet in containers

o Gekoelde en niet gevaarlijke stoffen
o Gekoelde en gevaarlijke stoffen
o Niet gekoelde en niet gevaarlijke stoffen
o Niet gekoelde en gevaarlijke stoffen

- Bulk

- Droge Bulk

- o Gekoelde en niet gevaarlijke stoffen
- o Gekoelde en gevaarlijke stoffen
- o Niet gekoelde en niet gevaarlijke stoffen
- o Niet gekoelde en gevaarlijke stoffen

Natte Bulk

- o Gekoelde en niet gevaarlijke stoffen
- o Gekoelde en gevaarlijke stoffen
- o Niet gekoelde en niet gevaarlijke stoffen
- o Niet gekoelde en gevaarlijke stoffen

12. Hoeveel bedragen voor deze categorieën en per modus gebruikt voor de verzending, de jaarlijkse tonnage en de gemiddelde partijgrootte (onder de "modus gebruikt voor de verzending" verstaan we deze die gebruikt wordt bij de start van het transport) ?

Geef eerst de totale jaarlijkse tonnage aan die u verzonden heeft.

Totale jaarlijkse tonnage: _ _ _ _ _ _ _ _ _ _ _

	Modus	Jaarlijkse tonnage	Gemiddelde partijgrootte (uitgedrukt in de gepaste eenheden; TEU voor containers, # palletten, # ton,...) #	eenheid
Categorie 1	Weg			
	Spoor			
	Binnenvaart			
Categorie 2	Weg			
	Spoor			
	Binnenvaart			
Categorie 3	Weg			
	Spoor			
	Binnenvaart			

B. Stated Preference Analyse

B. 1 Beschrijving van een typische goederenstroom

13. Beschrijf een typische goederenstroom aan de hand van de karakteristieken die in de volgende kader werden opgenomen.

Type goederen: .... (NaceBel Sector Code en preciseer)

Wat is het gemiddeld voorraadniveau van deze goederen in produktiedagen (cyclische voorraad): ....

Oorsprong (plaats van verzending)
Straat, nr.:
Plaats, postcode:
Land:

Bestemming:
Straat, nr.: ....
Plaats, postcode: ....
Land:

Afstand van het transport in km (enkel) : ....

Jaarlijks geladen tonnage voor deze goederenstroom: ....

Frequentie van de verzendingen per week: ....

Wat is de gemiddelde partijgrootte van de verzendingen: ....
(aanduiden in de gepaste eenheden; TEU, # palletten, # ton)

Omschrijf de bestemmeling:

- o Fabriek of productieatelier
- o Magazijn of logistiek platform
- o Groothandel
- o Kleinhandel

14. Beschrijf deze typische goederenstroom door de gepaste vakjes aan te duiden

Transportwijze	*Transportmodus*	*% van de tonnage*
- General Cargo ***- Containers*** o Gekoelde en niet gevaarlijk stoffen o Gekoelde en gevaarlijke stoffen o Niet gekoelde en niet gevaarlijke stoffen o Niet gekoelde en gevaarlijke stoffen ***- Niet in containers*** o Gekoelde en niet gevaarlijke stoffen o Gekoelde en gevaarlijke stoffen o Niet gekoelde en niet gevaarlijke stoffen o Niet gekoelde en gevaarlijke stoffen **- Bulk** ***- Droge Bulk*** o Gekoelde en niet gevaarlijke stoffen o Gekoelde en gevaarlijke stoffen o Niet gekoelde en niet gevaarlijke stoffen o Niet gekoelde en gevaarlijke stoffen ***Natte Bulk*** o Gekoelde en niet gevaarlijke stoffen o Gekoelde en gevaarlijke stoffen o Niet gekoelde en niet gevaarlijke stoffen o Niet gekoelde en gevaarlijke stoffen	1. o Wegvervoer 2. o Spoorwegen 3. o Binnenvaart 4. o Short Sea Shipping 5. o Maritiem 6. o Luchtvaart 7. o Pijpleidingen 8. o Multimodaal o 8.1 Weg – Spoor o 8.2 Weg – Binnenvaart o 8.3 Weg – SSS o 8.4 Spoor – Binnenvaart o 8.5 Spoor – SSS o 8.6 Binnenvaart – Maritiem o 8.7 Andere ___ - ___ o 8.8 Trimodaal ___ - ___ - ___	… … … … … … … … … … … … … … … …
Duid aan welke transporteenheden u gebruikt voor deze typische goederenstroom.		
o Oplegger o Mobiele laadeenheid o Container o Mega-railer o Andere, te preciseren:		
Geef aan of deze typische goederenstroom gekenmerkt wordt door beperkingen in verband met het transport (u mag meerdere opties aankruisen)		

1. o Geen specifieke voorwaarden, beperkingen 2. o Uitzonderlijke maten (projectcargo) 3. o Breekbare goederen 4. o Hygiëne (voedingsindustrie) 5. o Het gebrek aan behandelingsmateriaal bij de verzender beperkt de keuze van de modus 6. o Beperkte toegangsmogelijkheden bij de bestemmeling beperken de keuze van de modus 7. o De bestemmeling beperkt de keuze van de modus (op de één of andere manier) 8. o Andere :
Uitbesteden of zelf doen: Het transport wordt…
1. o Uitgevoerd voor eigen rekening 2. o Uitgevoerd door transporteur 3. o Uitbesteed aan logistieke dienstverlener 4. o Uitbesteed aan expediteur / forwarder 5. o Andere, gelieve te preciseren
Beschrijf de contractvoorwaarden voor deze typische goederenstroom met behulp van de "Incoterms"*. Omcirkel de gepaste aanduiding.
1. - Ex Works 2. - FCA, FAS, FOB 3. - CFR, CIF, CPT, CIP 4. - DAF, DES, DEQ, DDU, DDP

*** zie annex voor beschrijving van de verschillende Incoterms 2000**

15. Wat is de huidige waarde van volgende criteria die de keuze van de modus voor deze typische goederenstroom beïnvloeden?

Criteria	**Huidige waarde**
Kosten	
1. **Prijs** of kost voor het transport van Deur tot Deur per tonkilometer (laden en lossen inbegrepen)	… €
Kwaliteitscriteria	
2. **Tijdsduur :** Tijd van het transport van Deur tot Deur van verzender tot bestemmeling (laden en lossen inbegrepen)	… Uur
3. **Verlies en schade** uitgedrukt in het percentage verlies, diefstal of schade van de goederen	… %
4. **Frequentie** aangeboden door de vervoerder (aantal keer per week)	…
5. **Betrouwbaarheid** van de levertijd : aantal keer dat de verzending binnen de vooropgestelde termijn aankomt	… %
6. **Flexibiliteit** : % dat tijdig gereageerd wordt op onverwachte of niet geprogrammeerde aanvragen	… %
7. **Track & Trace** :	o Ja o Neen
8. **Andere**, te preciseren : ……………………………… ………………………………	

16. Rangschik bovenstaande criteria naar belangrijkheid in uw keuzeproces (gelijke waarden mogen voorkomen). Ken aan deze criteria ook gewichten toe (tussen o en 100). De gewichten moeten sommeren tot 100.

	Frequentie	**Tijdsduur**	**Betrouw-baarheid**	**Flexibiliteit**	**Prijs**	**% Verlies en schade**	**Tracking & Tracing**	**Andere**	**Andere**
Klassement									
Gewicht ($\sum=100$)									

17. Overweegt u in de toekomst een overstap te maken (of de mogelijkheid te bestuderen) naar een andere modus voor één of meerdere van uw goederenstromen?

Ja o - Neen o

Eventuele bedenkingen:

B.2 Stated Preferences

In dit tweede gedeelte zullen we een reeks alternatieven voorstellen voor de goederenstroom die u net heeft beschreven. Elk van deze alternatieven dient als realiseerbaar beschouwd te worden. Het is aan u om die alternatieven te rangschikken naar uw voorkeur. Hou er rekening mee dat het kiezen voor één van deze alternatieven kan inhouden dat er een andere modus gebruikt wordt!

De alternatieven worden gedefiniëerd aan de hand van zes variabelen, de frequentie van de dienst, de kost(prijs), de betrouwbaarheid van de levertijd, de levertijd zelf, de flexibiliteit en het percentage verlies van goederen. De waarden die u terugvindt op onze fiches zijn procentuele variaties op uw huidige situatie die werd voorgesteld onder vraag 15.

Na het SP-experiment

B.3 Hoe staat u tegenover een overstap naar een andere modus

18. Stel dat de alternatieven die u verkoos boven de huidige situatie aangeboden worden met een andere modus. Bent u in dit geval bereid om van modus te veranderen?

Ja ❑ - Neen ❑

⇒ Indien ja, ga naar vraag 19

⇒ Indien neen, ga naar vraag 21

19. => Voor welke alternatieven geldt dit? En voor welke modi? Wanneer u een intermodale optie opgeeft, specifieer dan de combinatie van de modi die gebruikt worden.

Alternatieven	Modi

20. => Noodzaakt dit een investering in materieel of infrastructuur op korte termijn?

Ja ❑ - Neen ❑

⇒ Indien ja, hoeveel bedraagt deze investering dan voor het geheel van de betrokken partijen (uw vestiging en andere partners of overheden)? (schatting) _ _ _ _ _ _ _ _€

⇒ En hoeveel bent u bereid hiervoor te betalen? _ _ _ _ _ _ _ _€

21. => Wenst u niet van modus te veranderen omdat dit een investering in materieel of infrastructuur noodzaakt?

Ja ❑ - Neen ❑

⇒ Indien ja, over welke som gaat het dan (schatting) ? _ _ _ _ _ _ _ _ _ €

⇒ Indien neen, zijn er dan andere redenen waarom u niet van modus wil veranderen?

Eventueel commentaar:

22. => Indien u niet van modus wenst te veranderen, kan u dan aangeven in welke mate één of meerdere attributen zouden moeten wijzigen om u toch te overtuigen?

Frequentie	Tijdsduur	Betrouwbaarheid	Flexibiliteit	Verlies	Kost
_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _

23. Indien u beslist om niet voor het geheel van deze typische goederenstroom een andere modus te gebruiken, maar wel voor een gedeelte, wat zou dan het percentage zijn dat wel met een andere modus (of andere modi, een intermodale optie kan ook) vervoerd zou worden (ken een % toe per modus) ?

Modi (te preciseren)	***% van het tonnage***

24. Ken een klassement toe aan onderstaande criteria in de mate dat zij belangrijk zijn voor uw beslissing.

	Frequentie	**Tijdsduur**	**Betrouw-baarheid**	**Flexibiliteit**	**Prijs**	**% Verlies en Schade**	**Tracking & Tracing**	**Andere**	**Andere**
Klassement									
Gewicht ($\sum$=100)									

Annex

De Incoterms 2000 zijn gestandaardiseerde definities van termen gebruikt in de internationale handel. Ze worden uitgegeven door de Internationale Kamer van Koophandel (Parijs). Deze termen zijn internationaal erkend als noodzakelijk bewijs van de verantwoordelijkheden voor koper en verkoper met betrekking tot de levering onder verkoopscontract.

Groep E Vertrek

Onder EXW minimeert de verkoper zijn risico. Hij is enkel verplicht de goederen in het eigen magazijn ter beschikking te stellen aan de koper.

- **EXW Ex Works (…named place) - Af fabriek (... genoemde plaats):**

Vervoer van de goederen: Het vervoer en uitklaren van de goederen wordt door de koper geregeld.

Risico's: Het risico gaat over van de verkoper op de koper wanneer de goederen ter beschikking worden gesteld van de koper.

Kosten: De koper draagt alle kosten vanaf het weghalen van de goederen van het bedrijfspand of het terrein van de verkoper naar de gewenste bestemming.

Wordt gebruikt voor elke transportmodus

Groep F Voornaamste transport niet betaald door verkoper

Onder Groep F, en onder FCA behalve anders overeengekomen, organiseert en betaalt de verkoper het voortransport in het land van export.

- **FCA Free Carrier (...named place) - Vrachtvrij vervoerder (... genoemde plaats):**

Vervoer van de goederen: De verkoper klaart de goederen uit, organiseert en betaalt het vervoer tot aan de plaats overeengekomen tussen koper en verkoper.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen op genoemde plaats ter beschikking worden gesteld van een transporteur aangeduid door de koper.

Kosten: De verkoper betaalt het transport tot aan de genoemde plaats. Het transport van deze plaats tot de gewenste bestemming wordt betaald door de koper.

Wordt gebruikt voor elke transportmodus

- **FAS Free Alongside Ship (…named port of shipment) - Franco langszij schip (... genoemde vertrekhaven):**

Vervoer van de goederen: Het schip en het natransport wordt betaald en georganiseerd door de koper. De verkoper neemt het voortransport voor zijn rekening en klaart de goederen uit.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen langszij het schip, op de kade, op trein of in lichters zijn geplaatst in de genoemde vertrekhaven.

Kosten: De kosten gaan over van verkoper op koper wanneer de goederen langszij het schip, op de kade, op trein of in lichters zijn geplaatst in de genoemde vertrekhaven.

Enkel gebruikt voor maritiem transport en binnenvaart verkeer.

- **FOB Free on board (…named port of shipment) - Vrij aan boord (... genoemde vertrekhaven):**

Vervoer van de goederen: Het schip en het natransport wordt betaald en georganiseerd door de koper. De verkoper klaart de goederen uit en neemt het voortransport inclusief laden van het schip voor zijn rekening.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen de scheepsreling zijn gepasseerd in de genoemde vertrekhaven.

Kosten: De kosten gaan over van verkoper op koper wanneer de goederen de scheepsreling zijn gepasseerd in de genoemde vertrekhaven.

Enkel gebruikt voor maritiem transport en binnenvaart verkeer.

Groep C Voornaamste transport betaald door de verkoper

Onder Groep C organiseert en betaalt de verkoper het voornaamste transport, maar het risico voor verlies en eventuele schade gaat over van verkoper op koper wanneer de goederen de scheepsreling passeren in de vertrekhaven.

- **CFR Cost and Freight (named port of destination) - Kostprijs en vracht (... genoemde aankomsthaven):**

Vervoer van de goederen: De verkoper klaart de goederen uit, sluit de zeevervoersovereenkomst af en betaalt de vracht tot in de haven van aankomst.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen de scheepsreling zijn gepasseerd in de genoemde vertrekhaven.

Kosten: De verkoper draagt de kosten tot de goederen zich in de aankomsthaven bevinden. Bovendien zijn de kosten van lossen voor zijn rekening wanneer dit zo in het contract staat gespecifieerd (for sellers/shippers account).

Enkel gebruikt voor maritiem transport en binnenvaart verkeer.

- **CIF Cost, Insurance and Freight (named port of destination) - Kostprijs, verzekering en vracht (... genoemde aankomsthaven):**

Vervoer van de goederen: De verkoper klaart de goederen uit, sluit de zeevervoersovereenkomst af en betaalt de vracht tot in de haven van aankomst.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen de scheepsreling zijn gepasseerd in de genoemde vertrekhaven. Bovendien sluit de verkoper een zeetransportverzekering af (tot op de kade in de aankomsthaven) en bezorgt de polis aan de koper. Op deze manier is die gerechtigd om rechtstreeks bij de verzekeraar een verzekeringsclaim in te dienen.

Kosten: De verkoper draagt de kosten tot de goederen zich in de aankomsthaven bevinden. Bovendien zijn de kosten van lossen voor zijn rekening wanneer dit zo in het contract staat gespecifieerd (for sellers/shippers account).

Enkel gebruikt voor maritiem transport en binnenvaart verkeer.

- **CPT Carriage Paid to (named place of destination) - Vrachtvrij tot (... named place of destination):**

Vervoer van de goederen: De verkoper klaart de goederen uit en betaalt de vrachtprijs voor het vervoer van de goederen naar de genoemde bestemming.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen onder de hoede van de vervoerder zijn gegeven.

Kosten: De verkoper draagt de kosten tot de overeengekomen plaats. Bovendien zijn de kosten van lossen voor zijn rekening wanneer dit zo in het contract staat gespecifieerd (for sellers/shippers account).

Wordt gebruikt voor elke transportmodus

- **CIP Carriage and Insurance Paid To (… named place of destination) - Vrachtvrij, inclusief verzekering tot (... genoemde aankomstplaats):**

Vervoer van de goederen: De verkoper klaart de goederen uit en betaalt de vrachtprijs voor het vervoer van de goederen naar de genoemde bestemming.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen onder de hoede van de vervoerder zijn gegeven. Bovendien sluit de verkoper een verzekering af voor het transport tot op de aankomstplaats en bezorgt de polis aan de koper. Op deze manier is die gerechtigd om rechtstreeks bij de verzekeraar een verzekeringsclaim in te dienen.

Kosten: De verkoper draagt de kosten tot de overeengekomen plaats. Bovendien zijn de kosten van lossen voor zijn rekening wanneer dit zo in het contract staat gespecifieerd (for sellers/shippers account).

Wordt gebruikt voor elke transportmodus

Groep D Aankomst

Onder Groep D maximeert de verkoper zijn kosten en risico omdat hij de goederen ter beschikking moet stellen op de overeengekomen bestemming.

- **DAF Delivered at Frontier (…named place) - Franco grens (... genoemde plaats):**

Vervoer van de goederen: De verkoper klaart de goederen uit en betaalt het vervoer tot over de grens. Het lossen komt voor rekening van de koper.

Risico's: Het risico gaat over van verkoper op koper wanneer de goederen ter beschikking worden gesteld van de koper.

Kosten: De kosten worden gedragen door de verkoper tot wanneer de goederen ter beschikking worden gesteld van de koper.

Wordt gebruikt voor elke transportmodus

- **DES Delivered Ex Ship (…named port of destination) - Franco af schip (... genoemde aankomsthaven):**

Vervoer van de goederen: De verkoper klaart de goederen uit en stelt de goederen ter beschikking van de koper aan boord van het schip in de aankomsthaven.

Risico's: De risico's verbonden aan het vervoer naar de aankomsthaven komen volledig voor rekening van de verkoper.

Kosten: De kosten verbonden aan het vervoer naar de aankomsthaven komen volledig voor rekening van de verkoper.

Enkel gebruikt voor maritiem transport en binnenvaart verkeer.

- **DEQ Delivered Ex Quay (…named port of destination) - Franco af kade (... genoemde aankomsthaven):**

Vervoer van de goederen: De verkoper klaart de goederen uit en stelt de goederen ter beschikking van de koper op de kade in de aankomsthaven. Kosten van behandeling komen voor rekening van de koper.

Risico's: De risico's verbonden aan het vervoer naar de aankomsthaven en het lossen van de goederen komen volledig voor rekening van de verkoper.

Kosten: De kosten verbonden aan het vervoer naar de aankomsthaven en het lossen van de goederen komen volledig voor rekening van de verkoper.

Enkel gebruikt voor maritiem transport en binnenvaart verkeer.

- **DDU - Delivered Duty Unpaid (…named place of destination) - Franco exclusief rechten (... genoemde aankomstplaats):**

Vervoer van de goederen: De verkoper klaart de goederen uit, organiseert en betaalt het vervoer en stelt de goederen ter beschikking op de overeengekomen aankomstplaats in het land van invoer. Het betalen van invoerrechten en soortgelijke belastingen en het vervullen van douaneformaliteiten komen ten laste van de koper.

Risico's: De verkoper draagt de risico's verbonden aan het vervoer om de goederen tot op de aankomstplaats te brengen.

Kosten: De verkoper draagt de kosten verbonden aan het vervoer om de goederen tot op de aankomstplaats te brengen exclusief invoerrechten en soortgelijke belastingen.

Wordt gebruikt voor elke transportmodus

- **DDP Delivered Duty Paid (…named place of destination) - Franco inclusief rechten (... genoemde aankomstplaats):**

Vervoer van de goederen: De verkoper regelt alle douaneformaliteiten - zowel in het land van invoer als in het land van uitvoer - organiseert en betaalt het vervoer en stelt de goederen ter beschikking op de overeengekomen aankomstplaats in het land van invoer.

Risico's: De verkoper draagt de risico's verbonden aan het vervoer om de goederen tot op de aankomstplaats te brengen.

Kosten: De verkoper draagt de kosten verbonden aan het vervoer om de goederen tot op de aankomstplaats te brengen inclusief invoerrechten en soortgelijke belastingen.

Wordt gebruikt voor elke transportmodus

Bronnen:

- International Chamber of Commerce, 1999. ICC publication n°. 614
- Vanheusden K., Witlox F. - Handelsverkeer en documentenstroom: INCOTERMS 2000: een overzicht. - Transportgids, Diegem, Kluwer, 2001, Afl. 2.9.1/1-2.9.1/49, p. 87-135

Annex 2-F

Enquête sur les critères qualitatifs déterminants le choix de mode de transport

Questionnaire réalisé conjointement par des équipes de l'UA-UFSIA (Antwerpen), UCL (Louvain-la-Neuve), FUCaM (Mons), RUG (Gent).

Table des matières

Le présent questionnaire concerne uniquement les expéditions faites par l'établissement

A. Caractéristiques de l'établissement

1. Veuillez compléter vos coordonnées ci-dessous.

1. Nom de l'établissement	:	___________________________
2. Adresse de l'établissement (rue, n° - ville - code postal)	:	__________________________ ___ _________________________ - ___________
3. Contact	:	___________________________
4. Téléphone	:	___________________________
5. Fax	:	___________________________
6. e-mail	:	___________________________
7. Secteur (code NaceBel)	:	___________________________
8. Nombre de salariés	:	2001 = _ _ _ _ _ _ 2000 = _ _ _ _ _ _ _ _ 1999 = _ _ _ _ _ _ _
9. Chiffre d'affaire (en €)	:	2001 = _ _ _ _ _ _ 2000 = _ _ _ _ _ _ _ _ 1999 = _ _ _ _ _ _ _

2. Quelle est la nature de l'activité principale de l'établissement ?

1. ❑ Usine ou atelier de production
2. ❑ Grossiste
3. ❑ Entrepôt ou plate-forme logistique
4. ❑ Autre : à préciser ……

A.1. Organisation du transport

3. Cochez la case adéquate concernant l'organisation du transport de vos expéditions (pour chaque question plusieurs réponses sont possibles) et veuillez mentionner le pourcentage y correspondant

	Vos Clients	Etablissement ou groupe (chargeur)		Prestataire mandaté à cet effet par votre établissement, entreprise ou groupe		
		Votre établissement	Votre entreprise ou groupe auquel votre établissement appartient	Transporteur[A]	Expediteur[B] (Forwarder)	Opérateur logistique[C]
Qui définit les options, les critères qualitatifs de choix d'un mode, et le choix des partenaires ?	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%
Qui organise les modalités de ce transport ?	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%
Qui exécute vos opérations de transport ?	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%	❑ _ _ _%

A : Transporteur : prestataire de service disposant de matériel roulant et qui se charge de transporter des marchandises pour compte d'autrui contre rémunération.

B : Expéditeur (Forwarder) : L'expéditeur est l'intermédiaire qui organise le transport des marchandises et les contrats. Il est possible qu'il choisisse le mode de transport et la route. Il sélectionne le transporteur, négocie les contrats de transport et de stockage et communique les informations et instructions. Il est chargé des opérations de transit et de dédouanement.

C : Opérateur logistique: Prestataire de service logistique utilise ses propres ressources, moyens et technologie pour offrir une chaîne de transport complète, comprenant le stockage, l'emballage, le suivi des commandes et les opérations de transport.

4. La décision d'organiser vos expéditions en compte propre ou d'externaliser (« outsourcing ») est avant tout motivée par un critère de coût (solution la moins chère) ou est-elle également motivée par des critères qualitatifs des services de transports? Cochez les critères qualitatifs qui ont influencé votre choix. [Plusieurs réponses sont possibles]

1. ❑ Coût payé (« out-of-pocket », y compris pour le chargement et déchargement)
2. ❑ Critères qualitatifs
   - ❑ Fiabilité des délais de livraison : % de fois que l'envoi arrive au moment prévu
   - ❑ Temps porte-à-porte (chargement et déchargement compris)
   - ❑ Fréquence des voyages offerts
   - ❑ Offre de suivi informatique du transport (Tracking and tracing)
   - ❑ Flexibilité du transporteur : capacité de répondre aux demandes non-programmées
   - ❑ Perte de marchandises (dommages, vols, accidents)
   - ❑ Autre(s): à préciser: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
     _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

5. Possédez-vous des véhicules et du matériel en propre ou en location longue durée pour le transport de vos expéditions?

1. ❑ Non
2. ❑ Oui →
   - ❑ Parc propre véhicules routiers (camionnettes, camions, tracteurs routiers) →
     - ❑ Camionnettes : Capacité de chargement (C)< 1 tonne
     - ❑ Camions : 10 tonnes < (C) < 23 tonnes
     - ❑ Tracteurs routiers : 23 tonnes < (C)
   - ❑ Parc propre ferroviaire →
     - ❑ Locomotives
     - ❑ Wagons
   - ❑ Parc propre fluvial (péniches, pousseur, barges fluviales) →
     - ❑ Péniches
     - ❑ Pousseur
     - ❑ Barges fluviales
   - ❑ Unités de transport intermodale (UTIs) →
     - ❑ Semi-remorque
     - ❑ Caisse mobile
     - ❑ Conteneur
     - ❑ Méga-railer

6. Quelles sont les conditions d'accessibilité aux infrastructures transport ? Avez-vous un accès direct (*) aux différents modes de transport? Et l'utilisez-vous pour vos expéditions?

(*) Un accès direct est compris comme n'ayant pas besoin de pré-transport en dehors du site de l'établissement pour atteindre les infrastructures.

	Accès direct	Utilisez-vous cet accès?	Si pas d'accessibilité directe : A combien de Km se trouve l'accès le plus proche ?	Utilisez-vous cet accès ?
1.Autoroute	Oui ❑ - Non ❑	Oui ❑ - Non ❑	……	Oui ❑ - Non ❑
2. Réseau ferroviaire	Oui ❑ - Non ❑	Oui ❑ - Non ❑	……	Oui ❑ - Non ❑
3. Voie navigable	Oui ❑ - Non ❑	Oui ❑ - Non ❑	……	Oui ❑ - Non ❑
4. Port maritime	Oui ❑ - Non ❑	Oui ❑ - Non ❑	……	Oui ❑ - Non ❑
5. Aéroport	Oui ❑ - Non ❑	Oui ❑ - Non ❑	……	Oui ❑ - Non ❑

A.2. Caractéristiques du transport

7. Quel est le budget de transport annuel de votre entreprise (estimation) pour l'année 2001 uniquement pour les flux sortants (en ne prenant pas en compte le transport des flux entrants et le transport interne à l'entreprise) ?

Valeur absolue	_ _ _ _ _ _ _ _ _ _ _ _ €
En % des coûts de production totaux	_ _ _ _ _ _ _ _ _

8. Pouvez-vous fractionner votre chiffre d'affaires par région de destination (selon leur part) et tranche de kilométrage, et répartir votre nombre total de clients par tranche de kilométrage (distance aller simple de l'établissement au destinataire) (pour les marchandises expédiées en 2001)?

Nombre total de clients	_ _ _ _ _ _ _

Région de destination	% du chiffre d'affaire
1. Benelux	_ _ _ _ _ _ _ _ _ %
2. France	_ _ _ _ _ _ _ _ _ %
3. Italie	_ _ _ _ _ _ _ _ _ %
4. Suisse	_ _ _ _ _ _ _ _ _ %
5. Espagne, Portugal	_ _ _ _ _ _ _ _ _ %
6. Allemagne	_ _ _ _ _ _ _ _ _ %
7. République Slovaque, République Tchèque	_ _ _ _ _ _ _ _ _ %
8. Pologne	_ _ _ _ _ _ _ _ _ %
9. Autriche, Slovénie, Hongrie	_ _ _ _ _ _ _ _ _ %
10. Estonie, Lettonie, Lituanie	_ _ _ _ _ _ _ _ _ %
11. Croatie, Bosnie Herzégovine, Yougoslavie	_ _ _ _ _ _ _ _ _ %
12. Ukraine, Biélorussie, Russie	_ _ _ _ _ _ _ _ _ %
13. Scandinavie, Danemark	_ _ _ _ _ _ _ _ _ %
14. Royaume-Uni, Irlande	_ _ _ _ _ _ _ _ _ %
15. Grèce, Turquie, Bulgarie, Roumanie et Albanie	_ _ _ _ _ _ _ _ _ %
16. Autre	_ _ _ _ _ _ _ _ _ %

	Nombre de clients (%)	% du chiffre d'affaires
1. < 250 Km	_ _ _ _ _ _	_ _ _ _ _ _ _ _ _ %
2. 250 – 500 Km	_ _ _ _ _ _	_ _ _ _ _ _ _ _ _ %
3. 500 – 1500 Km	_ _ _ _ _ _	_ _ _ _ _ _ _ _ _ %
4. > 1500 Km	_ _ _ _ _ _	_ _ _ _ _ _ _ _ _ %

9. Fractionner le tonnage total annuel de vos envois en % pour chaque mode utilisé (unimodal ou multimodal, unimodal signifie 1 mode pour 100% de la distance). Ceci concerne l'année 2001.

Modes		8. Quelle option multimodale ?	
1. ❑ Route	_ _ _ _ %	8.1. ❑ Route - ferroviaire	_ _ _ _ %
2. ❑ Ferroviaire	_ _ _ _ %	8.2. ❑ Route - fluviale	_ _ _ _ %
3. ❑ Fluviale	_ _ _ _ %	8.3. ❑ Route - SSS	_ _ _ _ %
4. ❑ Maritime	_ _ _ _ %	8.4. ❑ Ferroviaire - fluviale	_ _ _ _ %
5. ❑ Short Sea Shipping (SSS)	_ _ _ _ %	8.5. ❑ Ferroviaire - SSS	_ _ _ _ %
6. ❑ Aérien	_ _ _ _ %	8.6. ❑ Fluviale - maritime	_ _ _ _ %
7. ❑ Pipelines	_ _ _ _ %	8.7 ❑ Autre	
8. ❑ Multimodal →	_ _ _ _ %	_ _ _ _ _ - _ _ _ _ _	_ _ _ _ %
		8.8. ❑ Trois modes	
		_ _ _ _ _ - _ _ _ _ _ _ - _ _ _ _ _	_ _ _ _ %

10. Quelle est la valeur marchande moyenne des marchandises que votre entreprise envoie exprimée en Euro/ Kilogramme(valeur/ poids)?

- ❑ valeur < 6 €/ Kg
- ❑ 6 €/ Kg < valeur < 35 €/ Kg
- ❑ 35 €/ Kg < valeur

11. Quelle est la (ou quelles sont les) catégorie(s) de marchandise expédiée(s)?

- General cargo (Marchandises diverses)
  - Conteneurs
    - ❑ Non-dangereux et réfrigéré
    - ❑ Dangereux et réfrigéré
    - ❑ Non-dangereux et Non-réfrigéré
    - ❑ Dangereux et Non-réfrigéré
  - Non containérisé
    - ❑ Non-dangereux et réfrigéré
    - ❑ Dangereux et réfrigéré
    - ❑ Non-dangereux et Non-réfrigéré
    - ❑ Dangereux et Non-réfrigéré
- Vrac
  - Vrac sec
    - ❑ Non-dangereux et réfrigéré
    - ❑ Dangereux et réfrigéré
    - ❑ Non-dangereux et Non-réfrigéré
    - ❑ Dangereux et Non-réfrigéré

- Vrac liquide
  - ❑ Non-dangereux et réfrigéré
  - ❑ Dangereux et réfrigéré
  - ❑ Non-dangereux et Non-réfrigéré
  - ❑ Dangereux et Non-réfrigéré

12. Quels sont le tonnage annuel et la taille moyenne d'un envoi par mode utilisé pour la (ou les) catégorie(s) de marchandises mentionnée(s) ci-dessus (mode se comprend comme étant celui utilisé au départ de l'établissement, peu importe donc que vous utilisiez le multimodal)? Mentionnez également le tonnage total annuel expédié ?

Tonnage total annuel	_ _ _ _ _ _ _

	Mode	Tonnage annuel	Taille moyenne de l'envoi en unité appropriée (en TEU pour les conteneurs, palettes, barils, tonnes …) Taille	Unité
Catégorie 1	Route	_ _ _ _	_ _ _ _	_ _ _ _
	Ferroviaire	_ _ _ _	_ _ _ _	_ _ _ _
	Fluvial	_ _ _ _	_ _ _ _	_ _ _ _
Catégorie 2	Route	_ _ _ _	_ _ _ _	_ _ _ _
	Ferroviaire	_ _ _ _	_ _ _ _	_ _ _ _
	Fluvial	_ _ _ _	_ _ _ _	_ _ _ _
Catégorie 3	Route	_ _ _ _	_ _ _ _	_ _ _ _
	Ferroviaire	_ _ _ _	_ _ _ _	_ _ _ _
	Fluvial	_ _ _ _	_ _ _ _	_ _ _ _

B. Analyse de préférences déclarées

B.1. Flux de marchandises typique

13. Décrivez un flux typique (envoi) en termes des caractéristiques reprises ci-dessous

Type de bien : _ (Code NaceBel)

Quel est le niveau moyen des stocks en nombre de jour de production pour ce bien (cycle du stock):

_ _ _ _ _ _ _ _ _ _

Origine (adresse du site de départ de vos envois : _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

(rue et n° - ville - code postal) _ _ _ _ _ _ _ _ _ - _ _ _ _ _ _ _ _ _ _ _ _

Destination (adresse : rue et n° - ville - code postal - pays): _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ - _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _

Distance de transport en Kilomètre (aller simple) : _ _ _ _ _ _ _ _

Tonnage chargé annuel de ce flux : _ _ _ _ _ _ _ _ _ _

Fréquence des envois par semaine: _ _ _ _ _ _ _ _ _ _

Taille moyenne des envois : _ _ _ _ _ _ _ _ _ _ Unité (tonnes, TEU, palettes, barils…): _ _ _ _ _ _ _

Quel est le type de destinataire ? :

- ❑ Usine ou atelier de production
- ❑ Entrepôt ou plate-forme logistique
- ❑ Grossiste
- ❑ Magasin ou dépôt de vente

14. Décrivez ce flux typique selon les critères ci-dessous

Type de transport	*Mode de transport*	*% des tonnages*
- General cargo (Marchandises diverses)		
- Conteneurs	1. ❑ Route	….
❑ Non-dangereux et réfrigéré	2. ❑ Ferroviaire	….
❑ Dangereux et réfrigéré	3. ❑ Fluvial	….
❑ Non-dangereux et Non-réfrigéré	4. ❑ Maritime	….
❑ Dangereux et Non-réfrigéré	5. ❑ Short Sea Shipping	….
- Non containérisé	6. ❑ Aérien	….
❑ Non-dangereux et réfrigéré	7. ❑ Pipelines	….
❑ Dangereux et réfrigéré	8. ❑ Multimodal :	….
❑ Non-dangereux et Non-réfrigéré	8.1. ❑ Route - ferroviaire	….
❑ Dangereux et Non-réfrigéré	8.2. ❑ Route - fluviale	….
- Vrac	8.3. ❑ Route - SSS	….
- Vrac sec	8.4. ❑ Ferroviaire - fluviale	….
❑ Non-dangereux et réfrigéré	8.5. ❑ Ferroviaire - SSS	….
❑ Dangereux et réfrigéré	8.6. ❑ Fluviale - Maritime	….
❑ Non-dangereux et Non-réfrigéré	8.7. ❑ Autre, à préciser	….
❑ Dangereux et Non-réfrigéré	_ _ _ _ _ _ _ _ - _ _ _ _ _ _ _ _ _	
- Vrac liquide	8.8. ❑ Trois modes	….
❑ Non-dangereux et réfrigéré	_ _ _ _ _ _ - _ _ _ _ _ _ _ _ - _ _ _ _ _	….
❑ Dangereux et réfrigéré		
❑ Non-dangereux et Non-réfrigéré		
❑ Dangereux et Non-réfrigéré		

Mentionnez l'unité de transport spécifique utilisée pour ce flux

❑ Semi-remorque

❑ Caisse mobile

❑ Conteneur

❑ Méga-railer

❑ Autre : à préciser : _ _ _ _ _ _ _ _ _ _ _ _ _ _

***Mentionnez si cet envoi a des caractéristiques spécifiques contraignant le transport** (plusieurs options peuvent être choisies)*
1. ❑ Absence de contraintes particulières 2. ❑ Produits de grande dimension (project cargo) 3. ❑ Produits fragiles 4. ❑ Hygiène (industrie alimentaire) 5. ❑ La capacité des équipements à traiter la marchandise (matériel de manutention) à l'origine contraint le choix du mode 6. ❑ La capacité d'accessibilité du raccordement à destination contraint le choix du mode 7. ❑ Le destinataire contraint le mode à utilisé par choix 8. ❑ Autre, à préciser : _

Sous-traitance ou compte propre : Le transport a été
1. ❑ exécuté en compte propre 2. ❑ exécuté par un transporteur 3. ❑ sous-traité à un opérateur logistique 4. ❑ sous-traité à un expéditeur (forwarder) 5. ❑ autre, à préciser _ _ _ _ _ _ _ _ _
Décrivez l'imputation contractuelle des charges de transport de ce flux au moyens des « Incoterms* », entourez la mention adéquate
1. - Ex Works 2. - FCA, FAS, FOB 3. - CFR, CIF, CPT, CIP 4. - DAF, DES, DEQ, DDU, DDP

***INCOTERMS 2000: voir annexe pour une description détaillée**

15. Quelles sont les valeurs, correspondant à votre situation actuelle, des facteurs pris en compte dans votre choix de mode pour cet envoi typique ?

Critères	Valeur correspondant à votre situation actuelle
Coûts	
1. Prix par tonne-kilomètre de la facture pour le transport porte à porte (chargement et déchargement compris)	… €
Critères qualitatifs	
2. Temps : temps du transport porte-à-porte expéditeurs-destinataires en heures (chargement et déchargement compris)	… (en heures)
3. % de perte de marchandise (dommage, perte, vol)	… %
4. Fréquences : nombre de voyages offerts par semaine	….
5. Fiabilité des délais de livraison : % de fois que l'envoi arrive à l'heure (ou au moment) prévue	…. %
6. Flexibilité : % de fois que des demandes non programmées sont satisfaites à temps	…. %
7. Tracking and Tracing	❑ Oui ❑ Non
8. Autre(s), à préciser : _	- -

16. Attribuez un classement (un même classement peut être attribué à plusieurs critères), et un poids (compris entre 0 et 100, sachant que la somme des poids est égale à 100), aux critères ci-dessus selon l'importance qu'ils ont dans votre décision.

	Fréquence	**Temps**	**Fiabilité**	**Flexibilité**	**Prix**	**% de perte**	**Tracking & Tracing**	**Autre**	**Autre**
Classement									
Poids ($\sum$=100)									

17. Dans le futur, pensez-vous effectuer un changement de mode ou considérer (étudier) la possibilité de changer de mode, pour un ou plusieurs de vos flux de marchandises?

Oui ❑ - Non ❑

Commentaires éventuels:

B.2. Préférences déclarées

A présent, nous allons vous présenter une série d'alternatives de transport (25) pour lesquelles vous exprimerez un ordre de préférence (tout en tenant compte que ces alternatives pourraient impliquer ou non un changement de mode). Les alternatives se définissent en fonction de 6 critères, la fréquence, le coût, la fiabilité, la flexibilité, le temps de transport, et le % de perte de marchandise durant le transport. Ces critères peuvent prendre plusieurs niveaux, ces niveaux sont des % de variation par rapport à votre situation actuelle qui a été identifiée à la question 15. Durant cet exercice, chacune des alternatives doit être considérée comme réalisable.

Après l'exercice de préférences déclarées

B.3. Intentions de changement de mode

18. Pour les solutions préférées à votre option de statu quo, mais qui seraient offertes avec un mode alternatif, êtes-vous prêt à changer de mode ?

Oui ❑ - Non ❑

⇨ Si oui, allez à la question 19
⇨ Si non, allez à la question 21

19. => Si oui, pour quelles alternatives êtes-vous prêt à changer de mode ? Et pour quel(s) mode(s) ? Une option intermodale peut constituer un mode, spécifiez alors la combinaison des modes

Alternatives (n°)	Modes

20. => Si oui : Cela nécessiterait-il un investissement en équipement et/ou installation (à court terme) ?

Oui ❑ - Non ❑

⇨ Si oui, A combien s'élèverait cet investissement pour l'ensemble des parties (votre établissement et autres partenaires ou pouvoirs publics)? _ _ _ _ _ _ _ _ _ €

⇨ Et combien seriez-vous prêt à payer ? _ _ _ _ _ _ _ _ _ €

21. => Si non : la raison en est-elle qu'il faudrait consentir un investissement en équipement et/ou installation ?

Oui ❑ - Non ❑

⇨ Si oui, à combien s'élèverait cet investissement ? _ _ _ _ _ _ _ _ _

⇨ Si non, y a-t-il d'autres raisons pour lesquelles vous ne voulez pas changer de mode

Commentaires éventuels :

22. => Si non : Pouvez-vous indiquer quel niveau de variation d'un ou plusieurs attributs serait nécessaire pour vous faire changer ?

Fréquence	Temps	Fiabilité	Flexibilité	Perte	Coût
_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _

23. Si vous decidiez de ne pas changer de mode pour l'entièreté de ce flux typique, quel serait le % qui serait réorienté vers un ou plusieurs modes (une option intermodale étant comprise comme un mode) ? Attribuez un % à chaque mode

Modes, à préciser	*% du tonnage*

24. Attribuez un classement aux critères ci-dessous selon l'importance qu'ils ont pris dans votre décision

	Fréquence	**Temps**	**Fiabilité**	**Flexibilité**	**Prix**	**% de perte**	**Tracking & Tracing**	**Autre**	**Autre**
Classement									
Poids ($\Sigma=100$)									

Annexe

"Incoterms" est l'expression anglaise signifiant "termes du commerce international". Ce sont des termes commerciaux reconnus à l'échelle internationale, mis en place par la Chambre de Commerce Internationale, qui déterminent la dévolution du risque et des coûts au titre d'un contrat de vente international. Ces termes spécifient quelles sont les obligations des parties signataires du contrat en matière de transport, d'assurance, et de dédouanement import et export.

Groupe E

Sous EXW, le vendeur minimise ses risques, il est uniquement tenu de mettre sa marchandise à disposition de l'acheteur dans ses locaux propres ou dans un autre lieu convenu.

EXW « Ex Works » A l'usine (…lieu convenu):

Transport de la marchandise: Le transport est organisé par l'acheteur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise est mise à disposition de l'acheteur, le vendeur n'est pas responsable du chargement de la marchandise

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise ait été mise à disposition de l'acheteur, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour tous les modes de transport

Group F

Dans ce groupe d'incoterms, et sous FCA, sauf si un autre accord est convenu, le vendeur organise et paie pour le pré-transport dans le pays d'exportation, et dédouane la marchandise à l'exportation

FCA « Free Carrier » Franco transporteur (…lieu convenu):

Transport de la marchandise: Le transport est organisé par l'acheteur ou le vendeur au nom de l'acheteur

Risques: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été mise à la disposition du transporteur nommé par l'acheteur au lieu convenu

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise ait été mise à disposition du transporteur nommé par l'acheteur au lieu convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour tous les modes de transport

FAS « Free Alongside Ship » Franco le long du navire (…port d'embarquement convenu):

Transport de la marchandise: Le transport est organisé par l'acheteur

Risques: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été placée le long du navire au port d'embarquement convenu

Coût: Le coût est à charge du vendeur jusqu'au placement de la marchandise le long du navire au port d'embarquement convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

FOB « Free on board » Franco Bord (…port d'embarquement convenu):

Transport de la marchandise: Le transport est organisé par l'acheteur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise passe le bastingage du navire au port d'embarquement convenu

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise passe le bastingage du navire au port d'embarquement convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

Group C

Dans le groupe C, le vendeur arrange et paie pour le transport principal mais n'assume pas le risque

CFR « Cost and Freight » Coût et fret (…port de destination convenu):

Transport de la marchandise: Le transport est organisé par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise passe le bastingage du navire au port d'embarquement convenu

Coût: Le coût est à charge du vendeur jusqu'au port de destination convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

CIF « Cost, Insurance and Freight » Coût, Assurance et Fret (…port de destination convenu):

Transport de la marchandise: Le transport est arrangé par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise passe le bastingage du navire au port d'embarquement convenu. Mais le vendeur doit également souscrire une assurance maritime de couverture minimum.

Coût: Le coût est à charge du vendeur jusqu'au port de destination convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

CPT « Carriage Paid to Port » Port payé jusqu'à (lieu de destination convenu):

Transport de la marchandise: Le transport est arrangé par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été livrée au transporteur

Coût: Le coût est à charge du vendeur jusqu'au lieu de destination convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour tous les modes de transport

CIP « Carriage and Insurance Paid To » Port payé, assurance comprise, jusqu'à (lieu de destination convenu):

Transport de la marchandise: Le transport et l'assurance sont arrangés par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été livrée au transporteur. Mais le vendeur doit également souscrire une assurance de couverture minimum.

Coût: Le coût est à charge du vendeur jusqu'au lieu de destination convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour tous les modes de transport

Group D

Dans ce groupe d'incoterms, le vendeur assume un maximum du coût et du risque, il a dûment livré la marchandise lorsque celle-ci a été mise à disposition de l'acheteur au lieu de destination convenu

DAF « Delivered at Frontier » Rendu frontière (…lieu convenu):

Transport de la marchandise: Le transport est arrangé par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été livrée au lieu convenu à la frontière

Coût: Le coût est à charge du vendeur jusqu'à la livraison de la marchandise au lieu convenu à la frontière, à partir de ce moment là, le coût est à charge de l'acheteur

Habituellement utilisé pour le transport par route et par rail

DES « Delivered Ex Ship » Rendu ex ship (…au port de destination convenu):

Transport de la marchandise: Le transport est arrangé par le vendeur

Risques: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été mise à disposition de l'acheteur à bord du navire au port de destination convenu

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise ait été mise à disposition de l'acheteur à bord du navire au port de destination convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

DEQ « Delivered Ex Quay » Rendu à quai (…au port de destination convenu):

Transport de la marchandise: Le transport est arrangé par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise a été mise à disposition de l'acheteur à quai au port de destination convenu

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise ait été mise à disposition de l'acheteur à quai au port de destination convenu, à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

DDU « Delivered Duty Unpaid » Rendu droits non acquittés (…lieu de destination convenu):

Transport de la marchandise: Le transport est arrangé par le vendeur

Risque: Le risque est transféré du vendeur à l'acheteur quand la marchandise (non déchargée à l'arrivée de tout véhicule de transport) a été mise à disposition de l'acheteur au lieu de destination convenu

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise ait été mise à disposition de l'acheteur au lieu de destination convenu (non déchargée à l'arrivée de tout véhicule de transport), à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour la navigation maritime et intérieur

DDP « Delivered Duty Paid » Rendu droits acquittés (…lieu de destination convenu) :

Transport de la marchandise: Le transport est arrangé par le vendeur

Risques: Le risque est transféré du vendeur à l'acheteur quand la marchandise (non déchargée à l'arrivée de tout véhicule de transport) a été mise à disposition de l'acheteur au lieu de destination convenu

Coût: Le coût est à charge du vendeur jusqu'à ce que la marchandise ait été mise à disposition de l'acheteur au lieu de destination convenu (non déchargée à l'arrivée de tout véhicule de transport), à partir de ce moment là, le coût est à charge de l'acheteur

Utilisé pour tous les modes de transport

Source: International Chamber of Commerce, 1999. ICC publication n°. 614 (traduction de la version anglaise)
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ARTICLE

Determining the Monetary Value of Quality Attributes in Freight Transportation Using a Stated Preference Approach

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Ghent University, Department of Geography, B-9000 Ghent, Belgium ABSTRACT It is commonly accepted that the modal choice of a shipper is influenced not only by the pure economic attributes of transportation - time and cost - but also by more qualitative factors. These quality attributes relate to frequency, reliability, flexibility, transport duration and risk of loss or damage; they are usually difficult to quantify in monetary terms. Different techniques exist that help to understand better how these different quality attributes of freight transportation influence modal choice. In this paper we apply a stated preference design. Using real business data, the aim is then to derive partial utility functions that allow us to calculate monetary values for these different quality attributes.

KEY WORDS: Freight transportation; quality attributes; monetary values; stated preference

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Introduction

Today’s strong development of freight transportation, especially road transportation, brings with it many negative externalities such as road congestion and pollution. Therefore, bearing in mind the idea of sustainable development, policy makers are trying to promote a shift from road transportation to other modes such as inland navigation and rail. However, when analysing modal choice behaviour, it is not sufficient to take into account only transportation costs for developing an appropriate modal shift strategy. Other elements of a more qualitative nature should also be taken into account. These so-called quality of service attributes of freight transportation include frequency, reliability, flexibility, transport duration and risk of loss and damage. The purpose of this paper is to analyse how these quality of service attributes influence a shipper’s modal choice. To this end, use is made of a stated preference design.

Stated preference techniques are currently often used in transport economics, in particular for analysing passenger mode choice. Recently, however, a number of papers have emerged that also apply these techniques in the area of freight transportation. Worth mentioning in this respect are the contributions of Fowkes & Shingal, Fridstrøm & Madslien and Maier & Bergman, included in Danielis [1], and the contributions by Bolis & Maggi [2] and Jovicic [3]. Although it is interesting to note that more recent freight transport studies make use of stated preferences techniques, it can also be seen that the overall scope of these studies is often limited to specific transport alternatives (e.g. the choice between trucking and rail) whereby only a small number of influential explanatory variables (e.g. cost and time) are used. Hence, more research in freight transport modelling is needed that allows for more choice alternatives and for the use of more (nontraditional) explanatory variables. This is the purpose of the present paper. The paper is structured as follows.

First, a brief overview is presented of different transport mode choice determining attributes. Particular attention is paid to defining quality of service attributes since these attributes will be included explicitly in the freight transport choice modelling. The third section explains the use of the stated preference (SP) method, includes a short description of the questionnaire developed for the research, together with the design of the SP experiment. Then, the focus will be on the utility functions derived from the SP ranking. For that purpose, use is made of a software package □/ MUSTARD □/ that will help us to process and interpret the data used. In the final section it is demonstrated how the monetary equivalent of a quality attribute can be obtained. The application of the software and the computation of the monetary values will be illustrated from some tentative results.

Quality Attributes in Freight Transportation

A broad range of factors influences mode choice. Bierlaire *et al*. [5] even assert that it is impossible to incorporate all relevant elements into a single model, let alone to analyse and control them. Most researchers restrict themselves to one or two key dimensions when studying mode choice behaviour.

Quality of service attributes such as reliability, safety, damage susceptibility, information feedback (track and trace) and flexibility of response are all important factors that will greatly influence a consignor’s or carrier’s mode choice process. However, a lack of insight into these variables held back the development of mathematical models for predicting the future freight transport market or simulating the effects of policy measures, taking account of the aspect of quality of service [6]. Quality attributes in mode choice modelling in passenger transport have

already been widely studied and applied in practice. Therefore they will serve as a basis for modelling modal choice in freight transport, which has been studied far less extensively.
The modal attributes that may influence the choice can be divided into two major groups: (1) time and travel costs; and (2) quality of service attributes. Travel time and travel costs are identified in the literature as very significant to transport mode selection. These two factors are viewed both as quantitative transport characteristics [7□/10] and as qualitative characteristics [11□/17]. Travel time is one of the most important factors in explaining mode choice. Total travel time covers the period within which a particular journey, from origin to destination, is completed. Almost all of the above mentioned authors confirm the negative utility associated with an increase in the total travel time or one of its components.
The significance of time in freight transport will depend on the type of freight and the production system that is imposed by the supplier or customer. Moreover, travel time is usually given (for example, 'sailing time' in the case of maritime transport). The waiting time for loading or unloading, on the other hand, is variable and can influence transport performance quite profoundly. This already indicates that it is related to the quality attribute of 'reliability' [6].
Quality attributes mostly distinguished in the literature are reliability, information, comfort, convenience and safety and security. In the context of modal choice in freight transportation, the notion of reliability is usually associated with time. But reliability is generally interpreted more broadly than just a deviation from a scheduled timeframe. Punctuality, communication, respecting the terms of a contract and trust are all features of reliability [6].
A few studies also consider 'safety' and 'security' to be aspects of quality. The absence of loss or damage plays a key role in modal choice decisions, as each loss or damage implies a tangible loss in value of the freight. The probability that loss, theft or damage occurs is quite high, since freight transportation involves many handling operations.
In addition, freight transport accidents in comparison to passenger accidents are also usually quite substantial, due to the dimensions of the modes employed and/or the nature of the goods involved [6].

Methodology: Stated Preference

Stated Preference in Freight Transport Modes The use of stated preference techniques in freight transport modelling to calculate direct and cross price elasticities is not new [18□/20]. The point is that the problem of modal choice cannot be reduced to the mere choice of an acceptable transportation price, given that it also has to include qualitative factors [4].
In the literature two broad methods for the valuation of the 'quality' of transport can be found: 'revealed preference' and 'stated preference'. In the revealed preference (RP) method one observes the actual behaviour of a representative sample of respondents in order to obtain the required information regarding their valuation of quality. In the SP method, the respondent (in our case, shippers) is shown different sets of hypothetical choice options (transport alternatives), and is asked to choose among them or to allocate resources to them. Both RP and SP methods assume that an individual's behaviour is aimed at maximisation of utility. In Matear and Gray [21], Danielis [1] and Beuthe et al. [4] the SP method is used to evaluate quality attributes in freight transport [6].
The SP method has an advantage that the researcher has control over the attributes and the choice sets that are manipulated. It also allows the researcher to study how choices may vary if the size or composition of the choice sets are altered. This was not possible with the RP model. Another important characteristic of the SP approach is its ability to introduce and control certain choice constraints, such as time pressure, non-availability of preferred choice options, substitution effects, etc. It may also be argued that, although in RP modelling the

collection of the data is somewhat easier than for SP models, the latter approach is less expensive because the sample sizes needed to produce significant results are smaller.
The SP modelling technique also has a number of limitations. First, choice experiments are difficult to construct and the design of the survey is critical to its success. Therefore, it is essential to ensure that the hypothetical choice situations and the attributes used to define them are unambiguous and relevant to the choice maker's actual choice context. Second, SP models rely on the assumption that decisionmaking in quasi-laboratory conditions is related to real world choice behaviour. This raises the question of the external validity of the modelling approach. One could argue that only in a real world situation will people reveal their actual preferences. As such, given the risk that respondents may not necessarily do what they say, one could seriously doubt the validity assumption of the responses under experimental settings. In that case, the stated preference or choice may not correspond very closely with their actual preferences or choice as exercised in reality. In recent years, however, a substantial amount of empirical evidence has come to the fore in support of stated preference modelling [1].

Questionnaire and Experimental Design

An important prerequisite for a successful SP game is therefore a sound experimental design. To this end, a limited number of in-depth interviews were held with major industrial firms and logistic service providers located in the Antwerp and Ghent port areas in Belgium. In this way, both the design and the questionnaire were pre-tested and adjusted where necessary. The target group for the current research were shippers of goods in all possible industrial sectors with destinations in Europe. The transportation modes that were taken into consideration were road, rail, inland navigation, short sea shipping and all their inter- and multimodal combinations. A random sample population was drawn from all Belgian companies with at least 20 employees. Only the transport organisation of those companies was addressed. In total 88 companies participated.
All respondents were first asked to complete a more general questionnaire relating to the way the company organised its transport, and were subsequently invited to go through the SP design. The questionnaire used consisted of three parts. In the first part, the primary set of questions identified the general characteristics of the firm, more specifically, of the company from which the goods were transported. These data were used for a statistical cluster analysis of location, sector, number of employees and annual turnover. An additional set of questions focused entirely on the transport organisation of the firm. These questions mainly served to identify the decision process concerning transportation and the accessibility to the different transportation modes. A number of questions also related to modal distribution of the annual tonnage shipped goods. The second part of the questionnaire included an analysis of a typical goods flow of the company. This typical flow served as a reference flow for the stated preference experiment. The respondent was asked to denote a typical goods flow and to describe, in terms of origin and destination of the goods, distance covered, annual shipped tonnage, shipment size, means of transportation and transportation mode. One of the questions also related to a description of a typical flow in terms of the quality attributes of that flow and an indication of the relative weights of each of the quality attributes. This information is important for the analytical interpretation of the preference ranking provided by the stated preference experiment.
Having completed the questionnaire, respondents were then invited to play the SP experiment. Its main purpose was to identify the relative importance of a set of quality attributes by means of a ranking exercise of a set of different alternatives. We opted to use a ranking approach because it allowed us to complete more computations and it served better in identifying

possible lexicographic decision rules. The experiment itself was based on an orthogonal set of 25 transport alternatives, defined in terms of six quality attributes with each attribute having five levels [22].
The six attributes were defined as follows:

- Cost: the price of transportation, including loading and unloading.
- Time: the duration of transport, including loading and unloading.
- Loss and damage: the percentage of commercial value lost due to damage, theft and accidents.
- Frequency: number of services per week offered by the shipping company or forwarding agent.
- Reliability: percentage of the deliveries executed in time.
- Flexibility: percentage of unplanned shipments executed without excessive delay.

These quality attributes can vary with different levels. These levels are expressed as proportional changes with respect to the 'status quo' position (alternative 1), which represents the current status of the typical flow. This alternative is characterized by the fact that all attribute levels remain unchanged (0% change). Each alternative is presented to a respondent on a separate option card. Table 1 shows a selection of cards. Note that none of the alternatives refer to a specific transportation mode.
Each respondent was asked to rank each of the 25 alternatives according to overall attractiveness. The ranking was completed in two steps. First, the respondent indicated their preference by dividing the cards into three subgroups (most attractive, moderately attractive and least attractive). Next, the respondent ranked the cards within each subgroup. After the experiment the respondent was asked about the strategy they had applied for the ranking in order to understand their decision rules.
The alternatives included in the SP experiment were unrelated to the use of a specific transportation mode. Hence, an additional set of questions, to be completed after the stated

Table 1. Examples of transportation alternatives

	Frequency	Time	Reliability	Flexibility	Loss & damage	Cost
1	0%	0%	0%	0%	0%	0%
2	0%	+10%	+10%	+20%	−10%	−20%
3	0%	+20%	+20%	−20%	+10%	−10%
4	0%	−10%	−10%	+10%	−20%	+20%
5	0%	−20%	−20%	−10%	+20%	+10%
6	+10%	0%	+10%	+10%	+10%	+10%
...	...	...	...	...	...	...
15	+20%	−20%	+10%	0%	−20%	−10%
16	−10%	0%	−10%	−10%	−10%	−10%
17	−10%	+10%	−20%	0%	10%	+20%
...	...	...	...	...	...	...
23	−20%	+20%	+10%	−10%	0%	+20%
24	−20%	−10%	+20%	0%	−10%	+10%
25	−20%	−20%	−10%	+20%	10%	0%

preference experiment, was needed to reveal whether the availability of some of the preferred alternatives would lead to a modal shift, or under which circumstances a modal shift would be accepted. All data were processed using the software package MUSTARD [23].

MUSTARD

The software used to derive the partial utility functions, along with the 'part-worth utilities' of each of the attributes, is MUSTARD - 'Multicriteria Utility-based Stochastic Aid for Ranking Decisions' - based on the UTA-multicriteria analysis model of Jacquet-Lagre`ze & Siskos [24,25]. This approach to preference disaggregation relies on a goal programming model to evaluate an additive non-linear utility function from a preference ranking of alternatives. The method computes both the attributes' weights and equivalent money values for individual decision makers, and provides a good understanding of the respondents' preference system. The software also provides a double check of the interviews and interesting insights into each decision making approach. This is particularly valuable since freight demand is heterogeneous, as it is a derived demand for transporting goods with specific physical characteristics, from firms differently located within the transport network and characterized by different industrial processes and distribution organisation [2]. However, the main advantage of the method is that it estimates non-linear partial utility functions, whereas the usual discrete choice models only provide a linear utility function with constant coefficients.

Partial utility functions. Through the use of MUSTARD a general utility function can be built that represents the entire system of preferences of a decision maker with respect to the full set of criteria. The utility functions are additive, in the sense that the general utility of a certain alternative equals the sum of its partial utility functions of the respective criteria.

More formally, the following equation is obtained:

$$\Delta U = \alpha \cdot \Delta u_1 + \beta \cdot \Delta u_2 + \gamma \cdot \Delta u_3 + ... \qquad (1)$$

ΔU reflects the change of the general utility. The weights $\alpha, \beta, \gamma, \ldots$ determine how strongly changes in the partial utility of the different attributes $\Delta u_1, \Delta u_2, \Delta u_3, \ldots$ contribute to the general utility change.

The first component of equation (1) is represented by a piecewise linear partial utility function. The term 'partial' refers to the different attributes or criteria. These functions show how the utility level of a certain attribute changes in proportion to the current situation for altering values of that attribute.

Some results using MUSTARD. Based on the SP ranking data, MUSTARD is able to calculate for each of the six quality attributes a relative weight.

To illustrate, Table 2 depicts six company results from different industrial sectors where C_0 denotes the cost of transportation per ton-km.

From Table 2 it can be seen that the attribute 'cost' is the most important factor in five out of six cases. In some cases, in particular forthe steel industry, the weight of the cost factor is predominant.

If the other attributes are examined, it can be noted that they hardly play a part. Hence, they receive only a relatively small weight in the construction of the respondent’s utility function. Some differences however can be observed. For instance, the attributes ‘time’ and ‘reliability’ are important for those companies that trade in textiles and grain. The reliability factor is particularly important for the company that produces cooling machines - it even overshadows the cost factor. Note also that the steel company that ships its goods by inland navigation attaches much importance to the absence of ‘loss & damage’.

Using MUSTARD, partial utility functions can be generated. First, a small data transformation needs to be undertaken in order to understand better the interpretation of the resulting utility functions. All alternatives need first to be adjusted so that all negative changes are indeed reflected as ‘negative’ and all positive changes as ‘positive’. For example, when transportation time increases by 10% with respect to the current status, then this change should have a negative influence on utility, hence making the alternative less attractive. Although the increase in transportation time by 10% is noted on the cards as ‘+ 10%’, in fact this change has a negative meaning (-10%). Therefore a transformation is necessary (Table 3).

In the figures that follow, the different utility levels are shown on the vertical axis. They should be interpreted as variable contributions to the overall utility of a transportation service. The horizontal axis shows the changes in the attributes’ value. The ‘status quo’ position is represented by the point (0,0), where utility equals zero.

Let us take the example of the company that operates in plastics from Table 2. This particular company ships goods to Italy, over a distance of 963 km and uses only road transportation. The SP experiment showed that 11 out of 24 alternatives were preferred to the status quo position. The respondent declared to be prepared to change transportation modes, should the alternatives be executable.

Figures 1 to 5 represent the partial utility functions for each of the quality attributes obtained by using the MUSTARD software. Only the partial utility function for ‘loss and damage’ is left out because this attribute has a weight of zero, implying a full horizontal partial utility function.

Table 3. Signs adjustment according to meaning

	Frequency		Time		Reliability		Flexibility		Loss & damage		Cost	
Evolution	↑	↓	↑	↓	↑	↓	↑	↓	↑	↓	↑	↓
Cards	+	−	+	−	+	−	+	−	+	−	+	−
Software	+	−	−	+	+	−	+	−	−	+	−	+

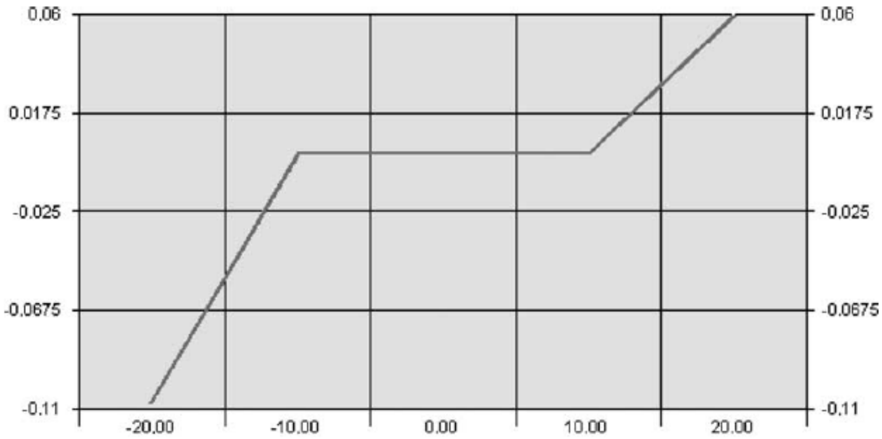

Figure 1. Partial utility function of ‘frequency’ (weight: 0.113).

Monetary Values

By means of the partial utility functions described above, different monetary values for increasing and decreasing values of a quality attribute in relation to the ‘status quo’ position can now be computed. These values indicate how much a company is willing to pay for an improvement in quality on the one hand and how much that same company wishes to receive as compensation for an inferior quality level on the other. The monetary equivalent of a quality attribute is computed by multiplying the trade-off between money, i.e. the transport cost, and its partial utility, with the trade-off between the utility of the attribute and its value. To illustrate, for a change of 20%, the willingness to pay (denoted WTP_C) and the willingness to accept compensation (denoted WTA_C) is expressed as follows:

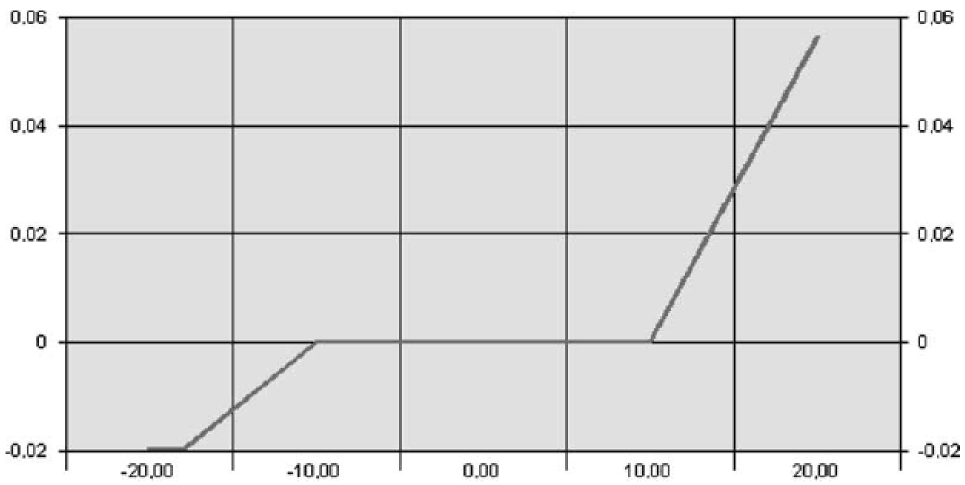

Figure 2. Partial utility function of ‘time’ (weight: 0.081).

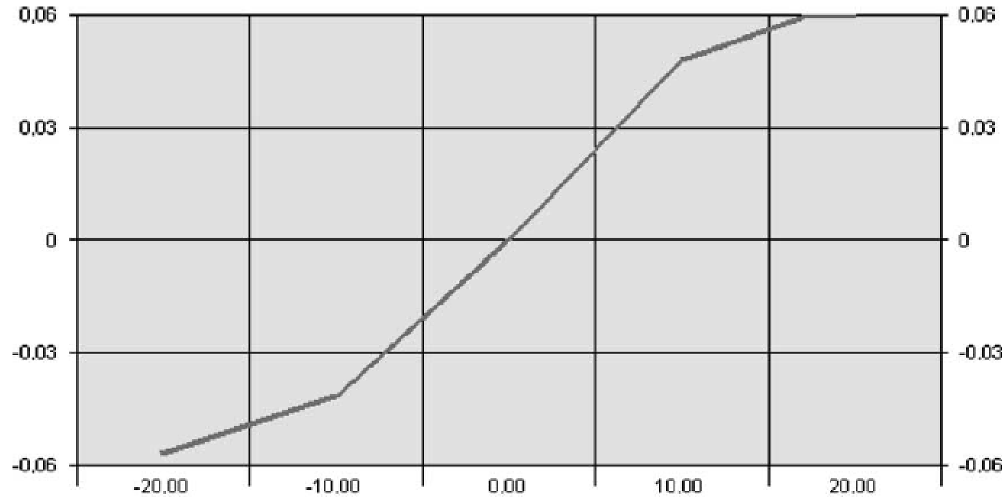

Figure 3. Partial utility function of ‘reliability’ (weight: 0.122).

$$WTP_C = \frac{C^{+20\%} - C_0}{u(C^{+20\%}) - u(C_0)} \quad (2)$$

and

$$WTA_C = \frac{C_0 - C_{-20\%}}{u(C_0) - u(C_{-20\%})} \quad (3)$$

Note that if the utility for each level of the attribute ‘cost’ is read from the MUSTARD graph or tables, the partial utility for this attribute at level +20% corresponds to the utility level indicated with $u(C_{-20\%})$. This is because an increase in cost has a negative effect, and will hence contribute to a decrease in utility. Consequently, the formulae can be rewritten as:

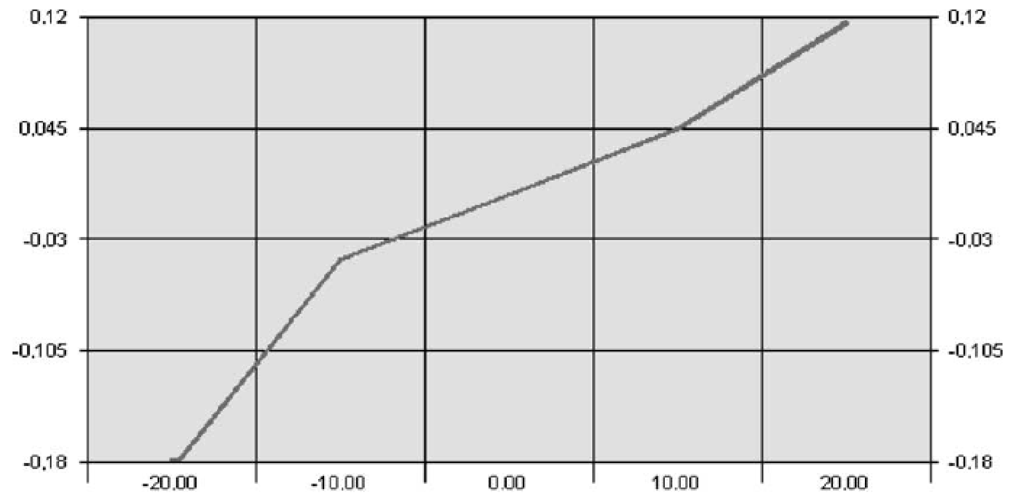

Figure 4. Partial utility function of ‘flexibility’ (weight: 0.302).

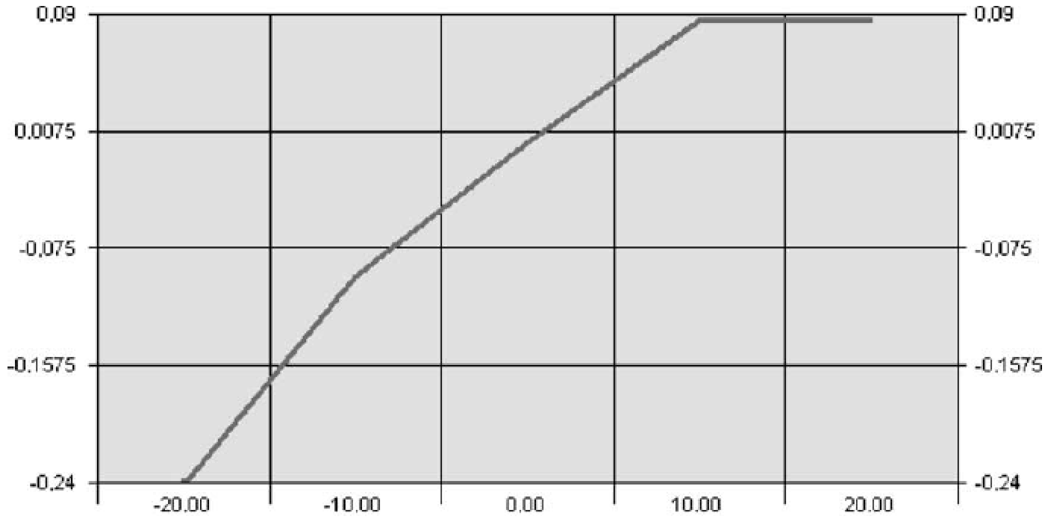

Figure 5. Partial utility function of 'cost' (weight: 0.328).

$$WTP_C = \frac{C^{+20\%} - C_0}{u(C_0) - u(C_{-20\%})} \quad (4)$$

and

$$WTA_C = \frac{C_0 - C_{-20\%}}{u(C^{+20\%}) - u(C_0)} \quad (5)$$

The ratio of the second trade-off, i.e. between the quality attribute and its value, is defined as follows:

$$Ratio_{+A} = \frac{u(A^{+20\%}) - u(A_0)}{A^{+20\%} - A_0} \quad (6)$$

and

$$Ratio_{-A} = \frac{u(A_0) - u(A_{-20\%})}{A_0 - A_{-20\%}} \quad (7)$$

where $Ratio_{+A}$ represents the ratio for an improvement in quality and $Ratio_{-A}$ represents the ratio for an inferior quality. As above, A_0 represents the actual value of the quality attribute at the 'status quo' level, $A^{+20\%}$, and $A_{-20\%}$ denotes the values of the attribute for the increase or decrease by 20%.

Note that, as with the utility of 'cost', the partial utility for the attributes 'time' and 'loss and damage' at level +20% corresponds to the utility level indicated with $u(A_{-20\%})$ (if we read the utility for each level of the attribute from the MUSTARD graphs or tables). This is also because an increase in time or loss implies a negative effect.

So, the willingness to pay for an increased quality equals $WTP_C * Ratio_{+A}$, and the willingness to accept compensation for a decreased quality equals $WTA_C * Ratio_{-A}$.

To illustrate, suppose, again for the company that trades in plastics, a change in the quality attribute ‘frequency’ of 20% would take place. It is obvious that the company will be prepared to pay extra for improved quality (frequency +20%). However, for a decrease in quality (frequency −20%), it will require compensation. We know from Table 2 that the transportation cost per ton-km (C_0) for the plastics company equals €0.254 (€1 =US$1.3). The partial utility in the status quo position $u(C_0)$ equals zero. From the graph of the partial utility function of the attribute ‘cost’, we can deduce the value of the transportation cost when increased or decreased by 20%, i.e. $C^{+20\%} = 0.305$ and $C_{-20\%} = 0.204$, and also the utility level in those points, i.e. $u(C^{+20\%}) = 0.086$ and $u(C_{-20\%}) = -0.242$. Using equations (4) and (5) the following results are found: $WTP_C = 0.347$ and $WTA_C = 0.163$.

From the questionnaire we know that the current frequency (F_0) of the number of shipments equals 23 per week. Similarly, we find that $F^{+20\%} = 27.6$, $F_{-20\%} = 18.4$, $u(F_0) = 0$, $u(F^{+20\%}) = 0.06$ and $u(F_{-20\%}) = -0.107$. The calculation of the second trade-off thus yields a ratio of 0.013 for an increased frequency (+20%) and 0.023 for a decreased frequency (−20%).

In order to find the monetary values both trade-offs yields have to be multiplied. Hence, the plastic producing company that is used here as an example would be prepared to pay an extra €0.0045 per ton-km for an increased frequency up to 27.6 shipments per week (i.e. multiplying equation (4) by equation (6)); but for a decreased frequency up to 18.4 shipments per week, the company will require compensation or reduction of €0.0038 per ton-km (equation (5) ×equation (7)).

One remark should be made concerning the computation of the monetary values. When computing all monetary values, we assume that an increase in the attribute’s value above 100% is possible and allowed. Mathematically this is incorrect and impossible, but in order to be able to compute the monetary values at the maximization point, we would need to know the weight at those points. However, the MUSTARD software only provides the weight of the attributes at the levels −20%, −10%, 0%, +10% and +20%.

Conclusion

Although it is commonly accepted that the modal choice of a shipper is influenced not only by the pure economic attributes of transportation such as time and cost, but also by more qualitative factors such as frequency, reliability, flexibility, transport duration, and risk for loss or damage, few freight transport mode choice modelling studies take account of these quality attributes. In the present contribution, however, an attempt has been made to do so using a stated preference design.

Stated preference techniques were found to be a robust methodology for trying to calculate monetary values for quality attributes in transport. The decision maker, in our case a series of companies, was given a set of hypothetical transportation choices for which they had to state their preference. The stated preference data used in this paper were taken from a survey of Belgian freight transport managers. These managers were first submitted to a questionnaire leading to an identification of a typical goods flow in terms of the quality attributes; this flow then formed the basis for the stated preference experiment.

The full ranking of the hypothetical alternatives to the shipper's current situation was processed using a software package called MUSTARD, based on the UTA-multicriteria analysis model, producing estimates of non-linear partial utility functions for each of the quality attributes; the usual discrete choice models provide only a linear utility function with constant coefficients. By means of those partial utility functions, different monetary values for increasing and decreasing values of a quality attribute in relation to the 'status quo' position were computed. These values indicate how much a decision maker is willing to pay for an improvement in quality on the one hand and how much they wish to receive as compensation for an inferior quality level on the other. The monetary equivalent of a quality attribute was computed by multiplying the trade-off between money, i.e. the transport cost, and its partial utility, with the trade-off between the utility of the attribute and its value.

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jaargang 40, nummer 3 Kwaliteitsattributen in het Tijdschrift goederenvervoer gemeten: een "stated preference" benadering Vervoerswetenschap Els Vandaele1 Frank Witlox2

Kwaliteitsattributen in het goederenvervoer gemeten: een “stated preference” benadering

Els Vandaele en Frank Witlox

1. Inleiding

Het doel van huidig onderzoek is na te gaan hoe verschillende kwaliteitsattributen van het goederenvervoer de modale keuze beïnvloeden. Die kwaliteitsattributen zijn onder andere frequentie, betrouwbaarheid, flexibiliteit, transporttijd en risico op schade en verlies. Door middel van "stated preference" technieken wensen we het beslissingsgedrag van transportmanagers of andere verantwoordelijken voor het verzenden van de goederen te onthullen. Het uiteindelijke doel is dan om aan die verschillende kwaliteitsattributen een monetaire waarde (elasticiteit) toe te kennen. Het onderzoek is nog niet afgerond, maar toch kunnen we al een aantal analyses maken op niveau van de individuele onderneming. Huidig onderzoek behoort tot het toepassingsgebied van "stated preference" technieken bij goederenvervoerstudies (Fowkes, 1989; de Jong, 2000; Danielis 2002), maakt een uitbreiding van deze studies en is specifiek gericht op de Belgische transportsector. Dit artikel vertrekt van een korte beschrijving van de vragenlijst die voor het onderzoek is opgesteld, samen met de opzet van het "stated preference" experiment. Daarna zullen we iets dieper ingaan op de nutsfuncties die we uit de "stated preference" rangschikking afleiden. Daartoe maken we gebruik van een softwarepakket (MUSTARD) dat ons helpt de gegevens te verwerken en te interpreteren. Ten laatste lichten we toe hoe het monetaire equivalent van een kwaliteitsattribuut wordt verkregen.We zullen de toepassing van de software en het berekenen van de monetaire waarden illustreren aan de hand van enkele voorlopige resultaten.

2. De vragenlijst en het "stated preference" experiment

De basis voor het onderzoek werd gevormd door een uitgebreide studie van de bestaande literatuur over modale keuze (Witlox, 2003). Daarnaast werd een aantal diepte-interviews gehouden bij grote industriële bedrijven en logistieke dienstverleners in de omgeving van de havens van Antwerpen en Gent. Op die manier hebben we de vragenlijst vooraf getest en aangepast waar nodig.De beoogde doelgroep voor huidig onderzoek zijn verzenders van goederen in alle mogelijke industriële sectoren met bestemmingen in Europa. De transportmodi die daarbij in aanmerking komen zijn weg, spoor, binnenvaart, kustvart (Short Sea Shipping) en al hun inter- en multimodale combinaties.De populatie waaruit de steekproef werd getrokken zijn alle Belgische ondernemingen met minstens 20 werknemers.We richten ons daarbij enkel op de transportorganisatie van de ondernemingen.

Summary

The purpose of current research is to analyse how different quality attributes of freight transportation influence modal choice.These quality attributes are among others. frequency, reliability, flexibility, transport duration and risk for loss or damage.We wish to disclose the decision behaviour of transport managers or other persons responsible for shipping the goods by means of "stated preference" techniques.The final goal is to attach a monetary value (elasticity) to those different quality attributes. For that purpose we use a specific software package (MUSTARD).The application of the software and the computation of the monetary values will be illustrated by means of some tentative results. The research project is still in progress, hence it is too early to draw general conclusions.The article cannot be seen as the final result. However, it does form an illustration of our findings at company level.The use of the MUSTARD software gives a view on the preferences and the decision process of transport managers. This method is also useful for analysing the precision of the "stated preference" experiment. Moreover, individual weights can be derived for each of the quality attributes. It also provides us monetary values for the willingness to pay for an improvement of quality an the willingness to accept compensations for a reduction in quality.

2.1 Vragenlijst

De vragenlijst is opgebouwd uit drie delen. In het eerste deel, dienden de eerste set van vragen voor het identificeren van de algemene karakteristieken van de onderneming, en meer bepaald van de onderneming van waaruit de goederen worden verzonden. Deze gegevens worden gebruikt om statistische clusteranalyses op locatie, sector, aantal werknemers en jaarlijkse omzet uit te voeren. Een tweede set vragen is volledig gericht op de transportorganisatie van de onderneming. Deze vragen dienden hoofdzakelijk om het besluitvormingsproces inzake transport in kaart te brengen, samen met de toegangsmogelijkheden tot de verschillende transportmodi. Er werd ook gevraag naar de verdeling van het jaarlijkse tonnage verzonden goederen over de verschillende gebruikte transportmodi. Het tweede deel omvat een de analyse van een typische goederenstroom voor de onderneming.Deze typische stroom zal als referentieverzending dienen voor het "stated preference" experiment. De respondent werd gevraagd een typerende goederenstroom aan te duiden en te beschrijven in functie van oorsprong en bestemming van de goederen, afgelegde afstand, jaarlijks verzonden tonnage, partijgrootte, gebruikt transportmiddel en -modus en contractvoorwaarden van het transport. Een van de vragen is erop gericht de typische stroom te beschrijven in termen van de kwaliteitsattributen van het transport.Deze informatie is essentieel voor de analytische interpretatie van de voorkeurrangschikking die het "stated preference" experiment oplevert.De laatste vraag van deel twee informeert naar de relatieve gewichten van elk van de kwaliteitsattributen. Het "stated preference" experiment dat erop volgt, heeft als doel het relatieve belang van die kwaliteitsattributen te identificeren. Het derde deel bevat nog enkele vragen over een eventuele verandering van modus (modale shift).

2.2 Experiment

Stated preference technieken worden momenteel vaak gebruikt in transporteconomie, bijvoorbeeld voor het analyseren van transportkeuzes en in het bijzonder keuzes gemaakt door reizigers.De laatste jaren is er ook een aantal onderzoeken gepubliceerd die deze technieken ook gebruiken op gebied van goederenvervoer.Noemenswaardig zijn de bijdragen van Fowkes et al. (1989), Bergkvist (1998), Jovicic (1998), Bolis en Maggi (1999), de Jong (2000), Danielis (2002) en Tavasszy et al. (2002). We hebben gekozen voor een rangschikking van de alternatieven (rangorde-methode) in het "stated preference" experiment. Die rangschikking moet enkel het relatieve belang van die kwaliteitsattributen identificeren. De respondent wordt apart ondervraagd over in welke omstandigheden hij welke vervoerswijze kiest. Het soort informatie verkregen via de rangorde-methode laat ook meer berekeningen toe, en kan zo ook mogelijke lexicografische beslisregels naar voor laten komen. In een later fase van het onderzoek zullen ook andere modellen zoals Multinomial Logit (MNL) en Artificial Neural Networks (ANN) aangewend worden om de verzamelde data te analyseren. Het experiment zelf is gebaseerd op een set van 25 transportalternatieven gedefinieerd in termen van zes kwaliteitsattributen met vijf attribuutniveaus (Addelman, 1962). Door gebruik te maken van een "fractional factorial design" worden enkel de hoofdeffecten van het design geschat. Het design is zo opgesteld dat deze hoofdeffecten onafhankelijk van elkaar worden geschat (orthogonaal). De zes kwaliteitsattributen werden als volgt gedefinieerd:

- KOST is de prijs van het transport inclusief laden en lossen;
- TIJD is de duur van het transport van deur tot deur, inclusief laden en lossen;
- VERLIES & SCHADE uitgedrukt als % van de commerciële waarde die verloren gaat ten gevolge van beschadiging, diefstal en ongelukken;
- FREQUENTIE van de dienst per week, aangeboden door de transportfirma of forwarder/expediteur;
- BETROUWBAARHEID als % van de leveringen tegen de vooropgestelde tijd;
- FLEXIBILITEIT als % van de keren dat een ongeplande verzending uitgevoerd is zonder overdreven vertraging.

De niveaus waarmee deze kwaliteitsattributen variëren, is uitgedrukt als een procentuele verandering op de "status quo" positie (alternatief 1), die de huidige situatie van de typische stroom weergeeft. Dit alternatief kenmerkt zich doordat alle attribuutniveaus niet wijzigen (0% verandering). Elk alternatief werd voorgesteld op een apart steekkaartje. In Tabel 2.1 staan enkele van deze kaartjes voorgesteld.Opgemerkt moet worden dat elk van deze alternatieven geen referentie naar een De respondent werd gevraagd elk van deze 25 alternatieven te rangschikken volgens aantrekkelijkheid. Het rangschikken gebeurde in twee stappen: eerst bepaalde de respondent zijn ruwe voorkeur door alle kaartjes over drie subgroepen (meest attractief,matig attractief en minst attractief) te verdelen, daarna legde hij/zij alle kaartjes binnen elke groep op volgorde. Na het experiment vroeg de interviewer op welke manier de respondent te werk ging. Hierbij werd nagegaan welke beslisregel de respondent gebruikte.

2.3 Modale shift

De alternatieven van het "stated prefrence" experiment zijn niet gerelateerd aan een bepaalde transportmodus. Daarom volgde er na het "stated prefrence" experiment een additionele set van vragen om na te gaan of de beschikbaarheid van enkele van de geprefereerde alternatieven tot een verandering van modus zou kunnen leiden, of onder welke omstandigheden een modale shift dan wel geaccepteerd zou kunnen worden. bepaalde transportmodus inhoudt.

3. MUSTARD

De software die gebruikt werd om de partiële nutsfuncties af te leiden, als ook de "part-worth utilities" van elk van de deelattributen, is MUSTARD (Scanella en Beuthe, 2001). MUSTARD staat voor "Multicriteria Utility-based Stochastic Aid for Ranking Decisions" en is gebaseerd op het UTA-multicriteria analysemodel van Jacquet-Lagrèze en Siskos (1978 en 1982).

3.1 Partiële nutsfuncties

Het uiteindelijke doel van MUSTARD is een algemene nutsfunctie op te bouwen die het systeem van voorkeuren van een beslissingsnemer met betrekking tot de volledige set van criteria zou moeten weerge- ven. De nutsfuncties zijn additief in die zin dat het algemene nut van een bepaald alternatief gelijk is aan de som van zijn partiële nutsfuncties op de respectievelijke criteria.Meer formeel bekomen we volgende vergelijking:

$$\Delta U = \alpha \,.\Delta u_1 + \beta \,.\Delta u_2 + \gamma \,.\Delta u_3 + \ldots \quad (1)$$

Tabel 2.1 Voorbeelden van transportalternatieven

	Frequentie	Tijd	Betrouwbaarheid	Flexibiliteit	Verlies en schade	Kost
1	0%	0%	0%	0%	0%	0%
2	0%	+10%	+10%	+20%	-10%	-20%
3	0%	+20%	+20%	-20%	+10%	-10%
4	0%	-10%	-10%	+10%	-20%	+20%
5	0%	-20%	-20%	-10%	+20%	+10%
6	+10%	0%	+10%	+10%	+10%	+10%
...	...	...	...	...	...	...
15	+20%	-20%	+10%	0%	-20%	-10%
16	-10%	0%	-10%	-10%	-10%	-10%
17	-10%	+10%	-20%	0%	10%	+20%
...	...	...	...	...	...	...
23	-20%	+20%	+10%	-10%	0%	+20%
24	-20%	-10%	+20%	0%	-10%	+10%
25	-20%	-20%	-10%	+20%	10%	0%

Tabel 3.1: Relatieve gewichten van de verschillende attributen

Bedrijf	**Textiel multimodaal 2104 km 120 uren $C_0 = 0.11$**	**Staal multimodaal 991 km 240 uren $C_0 = 0.038$**	**Staal binnenvaart 404 km 55 uren $C_0 = 0.017$**	**Koelmachines weg 1009 km 48 uren $C_0 = 0.24$**	**Graan weg 83 km 1.5 uren $C_0 = 0.12$**	**Plastiek weg 963 km 30 uren $C_0 = 0.254$**
Attributen						
Frequentie	0.081	0.007	0.003	0.055	0.263	0.113
Tijd	0.226	0.029	0.008	0.112	0.114	0.081
Betrouwbaarheid	0.144	0.114	0.001	0.315	0.146	0.122
Flexibiliteit	0.060	0.042	0.004	0.088	0.031	0.302
Verlies & schade	0.147	0.084	0.327	0.194	0.048	0
Kost	0.301	0.722	0.658	0.234	0.398	0.328

Opmerking: C0 staat voor de huidige kostprijs van het transport per tonkm
Bron: Beuthe et al. (2003), Enquête onderzoeksproject "Quality Differences between Freight Transport Modes"

waarbij ΔU de verandering van het algemene nut is. De gewichten α, $\beta, \gamma, \ldots$ bepalen hoe sterk de veranderingen in het partiële nut van de verschillende attributen $\Delta u1, \Delta u2, \Delta u3, \ldots$, bijdragen tot de algemene nutsverandering. De eerste component van vergelijking (1) wordt voorgesteld door een "piecewise linear partial utility function", waarbij de term partieel wijst op de verschillende attributen of criteria. Deze functies geven aan hoe het nutsniveau van een bepaald attribuut verandert in verhouding tot de huidige situatie voor veranderende waarde van dat attribuut.

3.2 Enkele MUSTARD resultaten

De gewichten die de respondent in de vragenlijst toekende aan de verschillende kwaliteitsattributen, kunnen getoetst worden aan de gewichten die we met behulp van MUSTARD verkrijgen. Het gebruik van de software kan geïllustreerd worden aan de hand van enkele resultaten van bedrijven uit verschillende industriële sectoren (zie Tabel 3.1).

Uit Tabel 3.1 kunnen we afleiden dat het attribuut "kost" de belangrijkste factor is in vijf van de zes gevallen.De andere kwalitatieve factoren spelen nauwelijks een rol en krijgen dan ook een relatief klein gewicht in de opbouw van de nutsfunctie van de respondent. De attributen "tijd" en "betrouwbaarheid" zijn belangrijk voor het textiel- en graanbedrijf. Voor de onderneming die koelmachines produceert, is vooral "betrouwbaarheid" belangrijk. Dit is te verklaren uit het feit dat een deel van de hogere transportkostprijs daar naartoe gaat. De staalonderneming die per binnenschip vervoert, hecht veel belang aan de afwezigheid van "verlies & schade".

MUSTARD genereert ook partiële nutsfuncties.Om de interpretatie van deze nutsfuncties beter te begrijpen, diende eerst een kleine transformatie te worden uitgevoerd. Alle alternatieven moesten getransformeerd worden zodat alle negatieve veranderingen als "negatief" werden voorgesteld en alle positieve veranderingen als "positief". Wanneer bijvoorbeeld de transporttijd met 10% toeneemt ten opzichte van de huidige situatie dan heeft dit een negatieve invloed op het nut en de besluitvorming. Hoewel de toename van de transportduur

Tabel 3.2 Aanpassing tekens naar betekenis

	Frequentie	Tijd	Betrouwbaarheid	Flexibiliteit	Verlies en schade	Kost
Evolutie	▲ ▼	▲ ▼	▲ ▼	▲ ▼	▲ ▼	▲ ▼
Kaartjes	+ -	+ -	+ -	+ -	+ -	+ -
Software	+ -	- +	+ -	+ -	- +	- +

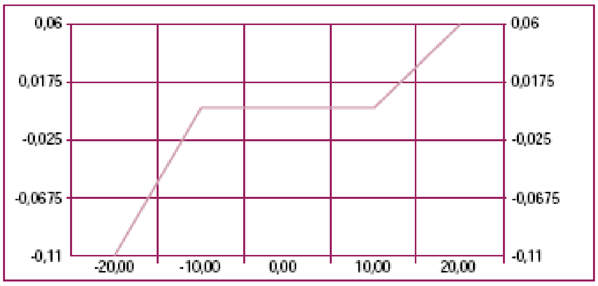
met 10% op de kaartjes staat vermeld als +10%", heeft ze in feite een negatieve betekenis (-10%).Deze transformaties worden weergegeven in Tabel 3.2.

In de figuren 1 tot en met 5 staan de verschillende nutsniveaus aangeduid op de verticale as.Zij moeten gezien worden als variabele bijdragen tot het algemene nut van een transportservice.De horizontale as geeft de veranderingen in de waarde van de attributen weer.De "status quo" positie wordt voorgesteld door het punt (0,0) waar het nut gelijk is aan nul.

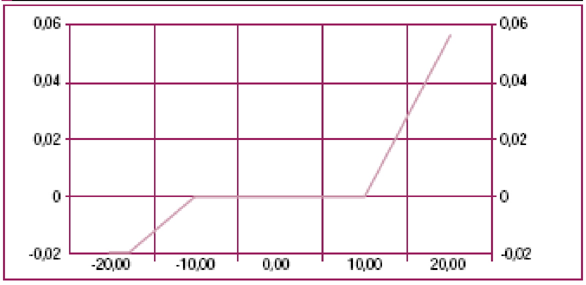
Laten we even, ter illustratie, het voorbeeld hernemen van de onderneming die handelt in plastiek uit Tabel 3.1. Deze onderneming transporteert goederen naar Italië,over een afstand van 963 km en gebruikt daartoe enkel wegvervoer. Uit het "stated preference" experiment bleek dat 11 van de 24 alternatieven boven de status quo positie werden verkozen. Mochten de alternatieven realiseerbaar zijn, dan verklaarde de respondent bereid te zijn van modus te veranderen.

De volgende figuren stellen de partiële nutsfuncties voor elk van de kwaliteitsattributen voor die we verkrijgen via de MUSTARD software. Enkel de partiële nutsfunctie voor "verlies & schade" is weggelaten omdat dit attribuut een verwaarloosbaar gewicht heeft en de partiële nutsfunctie bijgevolg volledig vlak is.

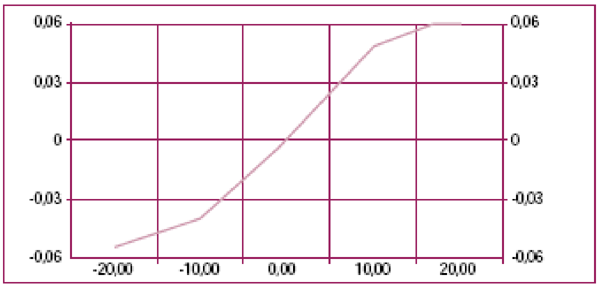
Figuur 3.1 Partiële nutsfunctie van "Frequentie" (gewicht: 0.113)



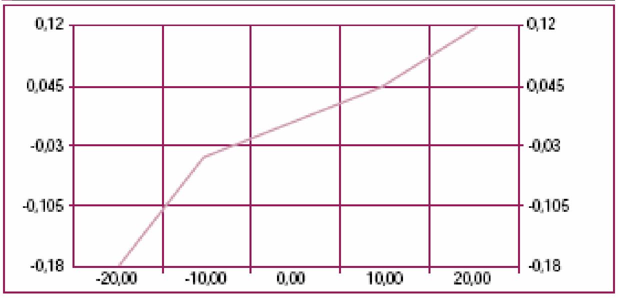
Figuur 3.2 Partiële nutsfunctie van "Tijd" (gewicht: 0.081)



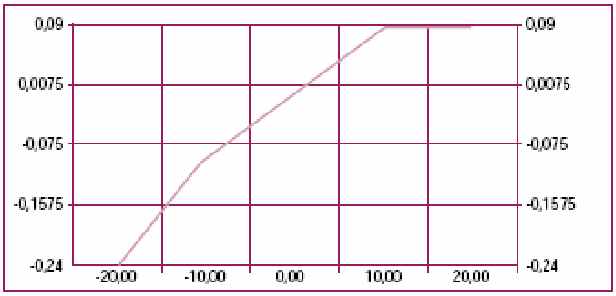
Figuur 3.3 Partiële nutsfunctie van "Betrouwbaarheid" (gewicht: 0.122)



Figuur 3.4 Partiële nutsfunctie van "Flexibiliteit" (gewicht: 0.302)



Figuur 3.5 Partiële nutsfunctie van "Kost" (gewicht: 0.328)



3.3 Monetaire waarden

Aan de hand van deze nutsfuncties kunnen we ook verschillende monetaire waarden berekenen voor stijgende en dalende waarden van een kwaliteitsattribut ten opzichte van de "status quo" positie. Deze waarden geven weer hoeveel de onderneming bereid is te betalen voor een verbeterde kwaliteit enerzijds, en hoeveel ze als compensatiewil ontvangen voor een verminderde kwaliteit anderzijds. Het monetaire equivalent van een kwaliteitsattribuut wordt berekend door het product te maken van de trade-off tussen geld, in dit geval de transportkostprijs, en zijn partieel nut, en de trade-off tussen het nut van het attribuut en zijn waarde.

Laten we even illustreren: stel dat we voor de onderneming die handeltin plastiek een wijziging in het niveau van het kwaliteitsattribuut "frequentie" van 20% willen onderzoeken. Voor een verbetering in kwaliteit (frequentie +20%) zal de onderneming bereid zijn meer te betalen,voor een verminderde kwaliteit (frequentie -20%) zal ze echter een compensatie willen ontvangen. De eerste trade-off, d.i. de bereidheid tot betalen, resp. tot aanvaarden van een compensatie, stellen we voor door de WTP_K en WTA_K,waarbij

$$WTP_K = \frac{K^{+20\%} - K_0}{u(K^{+20\%}) - u(K_0)} \text{ (1) en } WTA_K = \frac{K_{-20\%} - K_0}{u(K_{-20\%}) - u(K_0)} \text{ (2).}$$

De transportkost per tonkm (K_0) bedraagt € 0.254. De grafiek met de nutsfunctie van "kost" toont dat voor $K^{+20\%}$ - 0,305 en $K_{-20\%}$ - 0,204 het partiële nut respectievelijk $u(K^{+20\%})$ - 0,242 en $u(K_{-20\%})$ - 0,086. Na berekening bekomen we volgende waarden: WTP_K - 0.210 €/tonkm en WTA_K - 0.592 €/tonkm.
De ratio's van de tweede trade-off, d.i. deze tussen het nut van de frequentie en zijn waarde,worden als volgt gedefinieerd:
De huidige frequentie (F0) van het aantal verzendingen is 23 per week.

$$Ratio_{+F} = \frac{u(F^{+20\%}) - u(F_0)}{F^{+20\%} - F_0} \text{ (3) en } Ratio_{-F} = \frac{u(F_{-20\%}) - u(F_0)}{F_{-20\%} - F_0} \text{ (4).}$$

Ook hier kunnen we uit de grafiek met de nutsfunctie van "frequentie" afleiden dat voor $F^{+20\%}$ (27,6) en $F_{-20\%}$ (18,4) het partiële nut respectievelijk $u(F^{+20\%})$ - 0.06 en $u(F_{-20\%})$ - 0.107.De berekening van de twede trade-off levert een ratio op van 0,013 voor een verhoogde frequentie (+20%) en 0,023 voor een verlaagde frequentie (-20%). Door beide trade-offs met elkaar te vermenigvuldigen, bekomen we dat de onderneming uit het voorbeeld bereid zou zijn € 0,0027 per tonkm extra te betalen voor een verhoging van de frequentie tot 27,6 zendingen per week [(1)*(3)]. Voor een daling in frequentie tot 18,4 zendingen per week,zal de onderneming echter een prijsvermindering van € 0,0137 per tonkm ter compensatie willen [(2)*(4)]

Analoog kunnen ook de monetaire waarden van de andere kwaliteitsattributen berekend orden.Tabel 3.3 geeft een overzicht.De waarden zijn uitgedrukt in € per tonkm.

Tabel 3.3: WTP/WTA voor verandering in kwaliteit met 20%

	WTP voor betere kwaliteit (+20%)	WTA voor slechtere kwaliteit (-20%)
Frequentie	0,0027	0,0137
Tijd	0,0010	0,0012
Betrouwbaarheid	0,0007	0,0018
Flexibiliteit	0,0013	0,0058
Verlies en schade	0,0000	0,0000

Uit de bovenstaande tabel blijkt dat een lagere frequentie het zwaars zal doorwegen op de onderneming. Hier wordt immers de grootste compensatie gevraagd. De betalingsbereidheid voor een gewijzigde tijdsduur is ongeveer even groot bij een langere dan wel bij een kortere tijdsduur.

4. Besluit

Het onderzoeksproject waarvan in dit artikel de eerste resultaten werden besproken is nog niet afgerond, waardoor het te vroeg is om algemene conclusies te trekken. Dit artikel mag bijgevolg niet beschouwd worden als het uiteindelijke resultaat.Wel vormt het een illustratie van onze bevindingen op niveau van de individuele onderneming. Het gebruik van de MUSTARD software geeft een zicht op de voorkeuren en het beslissingproces van transportmanagers. Daarnaast is deze methode ook nuttig bij het nagaan van de juistheid van het "stated preference" experiment. Bovendien kunnen we individuele gewichten afleiden voor de verschillende kwaliteitsattributen en geeft het ons ook monetaire waarden voor de betalingsbereidheid voor een verbetering in kwaliteit en de bereidheid tot aanvaarden van compensaties bij een afname in kwaliteit. In een later stadium van het onderzoek zullen verdere econometrische analyses worden uitgevoerd om een verband te zoeken tussen de monetaire waarden en de kenmerken van de onderneming en de verscheepte goederen. Ook zullen de verkregen resultaten volgens deze onderzoeksmethode vergeleken worden met de resultaten die bekomen worden uit meer logistieke methoden. Al deze informatie kan gebruikt worden door professionele verladers om de markt van het goederentransport te verbeteren, maar evenzeer door de overheden bij de beleidsvorming, bijvoorbeeld bij het promoten van duurzaam ondernemen, bij het nemen van maatregelen inzake verkeer en infrastructuur, enz..

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A Multi-Criteria Methodology for Stated Preferences among Freight Transport Alternatives

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1 Introduction[1]

This paper presents a multi-criteria analysis of stated preference data, an approach we are experimenting to assess the relative importance of quality attributes in freight transportation, i.e. reliability, frequency, absence of losses, carrier's flexibility, and transport time. The overall objective is to better understand what determines the choice of a particular freight transport solution and/or mode. Given the continuous growth of freight transport, and the increasing congestion of roads and pollution, policy makers are attempting to promote a switch from trucking to other modes like inland waterways, short-sea shipping and rail, including combinations of these modes. Thus, it is particularly important to analyse how that can be organised and promoted given the determinants of transport mode choice.
Some useful information is available about freight transport price direct- and cross-elasticities, in Abdelwahab (1998), NEI (1999) and Beuthe et al. (2001) for instance. However, the problem of transportation choice cannot be reduced to the one of pricing alone but should also encompass the role of qualitative factors, which may bear upon the internal and external logistic organisation of the firms. These are not enough taken into account in previous studies. A stated preference approach can provide some additional information in that respect by assessing with transport managers the relative importance and value they give to service quality attributes. Hopefully, it should enable us to better value the real potential of a means/mode switching policy.
In Sect. 9.2, the paper gives a description of the questionnaire developed for this research and the experimental design that is used to elicit preferences from transport managers. Section 9.3 presents the multi-criteria methodology that we are experimenting with, the UTA multi-criteria method of preference des-aggregation of Jacquet-Lagrèze and Siskos (1978, 1982). It relies on a goal programming model to evaluate an additive non-linear utility function from an individual preference ranking of alternatives. It allows for the computation of the attributes' weights and equivalent money values for individual decision makers. Our survey is far from completed at this stage, so that Sect. 9.4 can only illustrate the methodology with some results obtained on a set of interviewed firms.

[1] This paper is one preliminary output of a research led by a Belgian consortium directed by M.Beuthe (Catholic University of Mons), H.Meersman and E.Van de Voorde (University of Antwerp), M. Mouchart (Catholic University of Louvain), and F.Witlox (University of Ghent). We thank the Belgian Federal Office for Scientific, Technical and Cultural Affairs (OSTC) for the financial support it granted to this project. A first version of this paper was presented at the European Regional Science Association conference in Jyväskylä (Finland) in August 2003.

2 The Questionnaire and Stated Preference Experiment

Stated preference techniques are currently used in the field of transport economics for analysing transport choices, particularly choices made by travellers. Much information about this field of enquiry and techniques can be found, for instance, in the recent Manual published by the U.K. Department of transport (2002). Over the last few years, some researches using that methodology have also been published in the field of freight transportation, and some recent contributions certainly deserve to be mentioned here: Fowkes and Shingai, Bolis and Maggi, Fridstrom and Madslien, Maier and Bergman, all of them edited in the book by Danielis (2002), but also Bergkvist (1998), Jovicic (1998), Matear and Gray (1993), NERA (1997), STRATEC (1999) and INRETS (2000), to name just a few. However, most of them limit their research to very specific transport alternatives, like the choice between trucking and rail inter-modal transport along a corridor, the choice between an external carrier and own-transport, or simply the value of time, etc. Moreover, samples are sometimes rather small given the number of explanatory variables that could play a role. Altogether, more research in this field is needed, particularly in the transport context of Belgium where no wider scope study has ever been made. These are the reasons that determined our involvement.

The techniques of interviews, which are necessary to elicit the decision makers preferences are well developed, and are extensively used in many fields, particularly in marketing analyses. They still are somewhat delicate to use, because interviews must be adjusted to the problem at hand, the nature of the sample, and the available budget. The associated questionnaire, including its experimental design, also raises many problems. Finally, the modelling of the decision problem and the techniques used to analyse the data constitute another area of research.

The stated preference data used in this paper are taken from a survey of Belgian freight transport managers, which is presently realised by a consortium of Belgian universities (Antwerp, Ghent, Louvain-la-Neuve, and Mons). The survey methodology and the questionnaire are based on an extensive survey of the transport, marketing and statistical literature in the field. Some contributors in the field are already mentioned in the introduction, but we should also cite Green and Srivinisan (1990), Huber and Zwerina (1996), Louvière et al. (2000), as well as Oppewal (1995a; 1995b), Carmone and Schaffer(1995), and Carroll and Green (1995) for reviews of techniques and available software. Additional references can be found in the survey paper by Louvière and Street (2000), as well as in the Manual of the U.K Department of Transport (2002).

Some preliminary in-depth interviews of transport managers were made in the course of preparing the questionnaire. Its feasibility was then pre-tested and adjusted accordingly. In the end, it is a compromise between a desire to gather as much useful information as possible and the practical consideration of a survey constraints. The choice of face-to-face interviews was made because it allowed the gathering of additional information in the course of the dialogue with the interviewee. The questionnaire and the stated preference experiment were administered on paper without any computer support. There are several reasons for this option that we discuss in the following paragraphs.

Previous studies on freight transport considered four to seven different attributes, among which our team was led to identify and define six relevant attributes. This is a number that the literature in the field considers as still feasible to handle in an interview. The purpose being to identify the attributes' relative importance in decision making, a full profile presentation of the six attributes characterizing each transport alternative was deemed more appropriate. To ease the task, we chose to present each alternative on a separate card; this conveniently permits to compare and rank all the alternatives, with the possibility of changing one's mind in the course of the interview. Also, we chose to demand only a full ranking of all alternatives, with no rating of preferences. Indeed, a ranking already provides a very rich information about the respondent's preference system. Additionally, we limited the number of alternatives by adopting a fixed orthogonal fractional factorial design of 25 alternatives, as proposed by Addelman (1962). Altogether, this task was deemed acceptable by a large majority of the people we have interviewed until now, i.e. about 100 people. Note that this experimental design implies that only the attributes' main effects on preferences can be analysed, whereas the effects of two attributes interaction are left aside.

The target population of the survey is the Belgian shippers of freight, which have at least 20 employees, in all industries and to any destination in Europe. Included among respondents are logistic operators and forwarders who manage shipments for industry. The modes of concern are: rail, road, waterway, short-sea-shipping, and their inter- and multi-modal combinations. Given the small size of the country, no location of origin is excluded, even though some modes may have a reduced accessibility like inland navigation in some provinces. Focusing on possible modal shifts, urban and distribution activities on short distances are excluded. Although there is a reduced opportunity over short distances for non-road transports, no minimum transport distance is set for the survey, since there are important cases of industrial goods that are transported over short distances by rail or inland navigation.

Unhappily, firms are often reluctant to be interviewed, so that a random sampling cannot be made, and the survey will be relatively small in size at around 125 firms. This led us to build a representative quota sample. Our target roughly is that each category of commodity in the sample should be in proportion to the shipments goods categories, that tonnages be in proportion to the shipments by each mode, and that shipments from different provinces be in proportion to their economic activities. Nevertheless, we should still be alert to the possibility that the assembled data could provide some biased information. A partial evaluation of that problem will be made by comparing the general characteristics of the firms that accepted the interview with those that refused the interview.

The face-to-face interviews are based on a questionnaire made of four parts: first, general questions about the characteristics of the firm and, more specifically, the characteristics and transport organisation of the plant from which shipping flows originate; second, the description of a typical transport flow that is used as a reference transport for the stated preference experiment; third, the stated preference experiment that aims at eliciting the relative importance of the quality attributes; fourth, a set of questions about the transport manager's readiness to accept a modal switch in order to obtain an alternative preferred to the reference situation.

The first set of questions concern the size of the firm, its type of operations, its accessibility to the transport network, how transport decisions are taken, etc. They provide information on the firms' transport situation and organisation that will be used as econometric explanatory variables in an ulterior phase of our research (when our survey will be completed). There is no point here to give more explanation about them.

The second part of the questionnaire is focused on a typical transport flow from the plant, which will be the reference shipment for the stated preference experiment. It leads the interviewee to choose and describe a typical specific flow: the specific good, its origin and destination, the distance, the annual tonnage, the shipments size and frequency, the type of consignee, the value and the characteristics of the transported good, etc. Then, the respondent must describe the typical flow in terms of the six transport attributes. Some of the criteria are defined in % of occurrences in order to encompass the idea of probability or risk affecting these criteria. They are defined in the following way:

- COST, i.e. out-of-pocket cost for transport, including loading and unloading;
- TIME, i.e. door-to-door transport time, including loading and unloading;
- LOSS as the % of commercial value lost from damages, stealing and accidents;
- FREQUENCY of service per week actually supplied by the carrier or the forwarder;
- RELIABILITY as the % of deliveries at the scheduled time;
- FLEXIBILITY as the % of times non-programmed shipments are executed without undue delay.

In the central part of the interview, the respondent is asked to rank various transport alternatives according to his/her preferences. The alternative solutions are defined in terms of all six attributes; it is a full profile representation, as explained above. The levels of attributes are given in percentages of variation from the status quo situation, the latter being the typical flow's current transport solution. The respondent is invited to keep in mind this typical flow and to interpret the percentage variations in terms of that reference situation. Some alternatives are shown in Table 1. Their definition conveniently allows the use of the same set of alternatives and cards for all respondents even though their reference typical flow is different. It also clearly defines the appropriate reference situation from which a potential switch should be envisaged (Department for Transport 2002, Ch.12).

As shown in Table 1, only five levels of variation are considered: plus or minus 10%, plus or minus 20%, and the status quo level of 0% variation. In this table, alternative 1, with zero percentage of variation for every attribute, obviously corresponds to the status quo solution. In contrast, alternative 2 compared to the status quo is characterized by a 10% increase of both transport time and reliability, a 20% increase of flexibility, a 10% decrease of loss and a 20% cost decrease. For example, this means that, if the cost of a reference typical flow is 100 EURO and its reliability is at the level of 70%, the cost of alternative 2 is only 80 EURO and its reliability improved at the level of 77% [2].

[2] In some cases, the status quo may very well have an attribute with value close or equal to 100% (or 0%). This would constraint a positive % variation (or a negative one). Such a situation is pointed out to the decision maker who should take it into account in his / her preference ranking.

Table 1. Some examples of full profile alternatives

	Frequency	Time	Reliability	Flexibility	Loss	Cost
1	0%	0%	0%	0%	0%	0%
2	0%	10%	10%	20%	–10%	–20%
3	0%	20%	20%	–20%	10%	–10%
4	0%	–10%	–10%	10%	–20%	20%
5	0%	–20%	–20%	–10%	20%	10%
6	10%	0%	10%	10%	10%	10%
-	-	-	-	-	-	-
15	20%	–20%	10%	0%	–20%	–10%
16	–10%	0%	–10%	–10%	–10%	–10%
17	–10%	10%	–20%	0%	10%	20%
-	-	-	-	-	-	-
23	–20%	20%	10%	–10%	0%	20%
24	–20%	–10%	20%	0%	–10%	10%
25	–20%	–20%	–10%	20%	10%	0%

All this is carefully explained at the beginning of the experimental game, and the interviewee is invited to keep in mind the attributes' absolute levels of the reference typical flow.
Given that the interviews are face-to-face with the possibility of helping the decision maker and listening to his/her oral comments, some useful additional information may be gathered. Likewise, the interviewer observation of the actual preference ranking provides a better understanding of its process, as well as insights into whether the decision maker ranks according to a lexicographic order or uses threshold values in assessing alternatives, etc. These observations are useful for interpreting the individual decision maker's preferences and checking the results of ulterior analyses.
It must be underlined that none of the alternatives is explicitly characterised by a specific mode use. However, the status quo solution may very well be associated with its actual mode in the respondent's mind. Clearly, we can presume that the hypothetical solutions preferred by the respondent would be chosen if they were available without any modal switch, but we cannot necessarily infer from the preference order that a modal shift would be accepted. In order to find out whether some preferred alternatives would be chosen even if they required a modal shift, additional questions focusing on that problem are raised in the fourth part of the survey. They investigate whether the respondent has ever considered switching mode, whether there would be obstacles to do so, and whether he/she would actually switch mode if another mode was able to provide one of the preferred alternative. This additional information will permit a more precise interpretation of the stated preference data by allowing to check whether the information conveyed by the individual preference statements can really be used for analysing the modal choice decision of the respondents.

3 The UTA Model

Like most multi-criteria approaches, the UTA model aims to estimating a utility function or utility values. This terminology is maintained here and throughout the paper more for convenience than for substance. Actually, a more neutral terminology like “decision function” or “value function” could be appropriate. Indeed, it is not obvious that a competent transport manager thinks in terms of maximizing a utility value. They likely rather try to minimize some measure of the total transport logistic cost, which integrates many internal and external logistic factors that are function of the transport attributes. Hence, the utility terminology does not have any substantial significance for the following analysis, despite the fact that the concept of logistic cost may still involve a somewhat subjective judgment on risk taking, since it is influenced by the management of safety stocks.

As mentioned above, our survey is far from completed, so that we did not yet venture in any aggregate econometric analysis of a sample. However, this multi-criteria method, rather unusual in the field, allows to compute the attributes’ weights and equivalent money values for individual decision makers. In this way, it contributes to a better understanding of the interviewed individuals’ preference system, permits a double check of the interviews and gives interesting insights in each decision making approach. This is particularly valuable in a first stage analysis, since freight demand is heterogeneous, from firms characterized by different industrial processes and outputs as well as different accessibility to the transport network (Bolis and Maggi 2002). Another advantage of the method is that it estimates non-linear utility functions, whereas the usual discrete choice models provide only a linear utility function with constant coefficients.

It is a model specifically designed to derive utility functions on the basis of a preference ranking. Hence, it is particularly appropriate to our purpose and our data. Indeed, the problem here is to compare, rank and value a set of actions, or choice alternatives, with respect to N different criteria which contribute to the alternatives’ utility. The criteria’s values are given by the vector $g(a) = (g_1(a), g_2(a), \ldots, g_N(a))$ for any alternative a belonging to A. As an example, for a highway project, the $g_i(a)$’s could be the cost-benefit ratio, its favourable impact on safety, on environment, etc. In our case, the criteria will be the characteristics of the transport solutions under consideration: their Cost, Reliability, Frequency, Flexibility, Time, and Safety. These characteristics were discussed and defined in Sect. 9.2.

The model assumes the existence of a utility function:

$$U(g(a)) = U(g_1(a), g_2(a), \ldots, g_N(a)), \qquad (9.1)$$

which satisfies the classic axioms of decision theory, namely the axioms of comparability, reflexivity, transitivity of choices, continuity and strict dominance.

The utility function is additive,

$$U(g(a)) = \sum_{i=1}^{N} u_i(g_i(a)) \qquad (9.2)$$

with

$$u_i(g_i) \geq 0 \text{ and } \frac{du_i}{dg_i} > 0. \qquad (9.3)$$

The additive function implies in particular that the partial utility of a criterion $u_i\ (g_i\ (a))$ depends only on the level of that particular criterion[3]. Equation (9.3) guarantees that the functions are monotone increasing with respect to increasing levels of a favourable attribute. Hence, each attribute must be defined as a favourable factor. In our case, this means that the cost and time attributes must be sign-inverted to fit in the model. Equation (9.3) can be seen as a minimal requirement of judgement rationality.
The utility function provides an aggregation of the criteria in a common index to compare and value the alternatives under consideration. It ranks the project in a complete weak order R : if P indicates a strict preference and I the indifference between two projects a and b, then

$$U[g(a)] > U[g(b)] \Leftrightarrow aPb \qquad (9.4)$$

$$U[g(a)] = U[g(b)] \Leftrightarrow aIb \qquad (9.5)$$

The UTA method, proposed initially by Jacquet-Lagreze and Siskos (1978, 1982), estimates the function U on a set of reference alternatives projects A, by the method of linear goal programming proposed by Charnes and Cooper (1961, 1977), which provides an approximation by linear intervals of a non-linear function.
In order to apply that method, the field of variation of each criterion $\left| g_{i^*}, g_i^* \right|$, defined by its least favourable value of that criterion (g_{i^*}) and its best value (g_i^*), is divided in α_i equal intervals $\left| g_i^j, g_i^{j+1} \right|$. The variables to be estimated by the program are the partial utilities at these bounds, say $u_i(g_i^j)$. The utility at intermediate values of the criteria are given by linear interpolation. Thus, for $g_i(a) \in \left[g_i^j, g_i^{j+1} \right]$,

$$u_i[g_i(a)] = u_i(g_i^j) + \frac{g_i(a) - g_i^j}{g_i^{j+1} - g_i^j}\left[u_i(g_i^{j+1}) - u_i(g_i^j)\right] \qquad (9.6)$$

For each pair of transport alternatives (a, b) belonging to A, the decision-maker must express his/her preferences or indifferences. Under the version proposed by Despotis et al. (1990), the so-called UTASTAR version, the results of these comparisons are introduced as constraints consistent with Eqs.(9.4–5), i.e.

$$\sum_{i=1}^{N} \{u_i(g_i(a)) - u_i(g_i(b))\} + \sigma^+(a) - \sigma^-(a) - \sigma^-(b) + \sigma^-(b) \geq \delta \Leftrightarrow aPb \qquad (9.7)$$

$$\sum_{i=1}^{N} \{u_i(g_i(a)) - u_i(g_i(b))\} + \sigma^+(a) - \sigma^-(a) - \sigma^+(b) + \sigma^-(b) = 0 \Leftrightarrow aIb \qquad (9.8)$$

with all σ^+ and $\sigma^- \geq 0$.

[3] For a discussion about additive utility functions see Keeney and Raiffa (1976) and Fishburn (1967).

σ^+ corresponds to a positive error with respect to the difference between utility levels, whereas σ^- indicates a negative error. These errors are all non-negative, they represent the possible errors of an action's utility estimation. The objective function F to be minimised is the sum of these errors:

$$F = \sum_{a \in A'} \left| \sigma^+(a) + \sigma^-(a) \right| \qquad (9.9)$$

The parameter δ on the right side of Eq. (9.7) must be strictly positive. Its value can very well influence the solution of the program. Hence, in the course of estimation, it must not initially be given a high value (Beuthe and Scannella 1996, 2001). The hypothesis that the partial utilities increase with the value of the criteria imposes a series of additional constraints:

$$u_i(g_i^{j+1}) - u_i(g_i^j) \geq s_i \qquad j=1,2,...,\alpha_i \text{, and } i=1,2,...,N \qquad (9.10)$$

where s_i must be (strictly) positive. Like for δ, it is better initially to give it a small value. Finally the partial utilities are normalised by the conditions

$$\sum_{i=1}^{N} u_i(g_i^*) = 1 \text{,} \qquad (9.11)$$

and

$$u_i(g_{i^*}) = 0 \qquad \forall\ i \qquad (9.12)$$

Equation (9.10) indicates that the values of $u_i(g_i^*)$'s, the criteria's utilities at their highest levels, correspond to the criteria's relative weights in the utility function.
Putting together all these elements, the following linear program is obtained:

$$\min F = \sum_{a \in A'} \left| \sigma^+(a) + \sigma^-(a) \right| \qquad (9.13)$$

subject to:

$$\sum_{i=1}^{N} \{u_i(g_i(a)) - u_i(g_i(b))\} + \sigma^+(a) - \sigma^-(a) - \sigma^+(b) + \sigma^-(b) \geq \delta \Leftrightarrow aPb \qquad (9.7)$$

$$\sum_{i=1}^{N} \{u_i(g_i(a)) - u_i(g_i(b))\} + \sigma^+(a) - \sigma^-(a) - \sigma^+(b) + \sigma^-(b) = 0 \Leftrightarrow aIb \qquad (9.8)$$

$$u_i(g_i^{j+1}) - u_i(g_i^j) \geq s_i \qquad j=1,2,...,\alpha_i \text{, and } i=1,2,...,N \qquad (9.10)$$

$$\sum_{i=1}^{N} u_i(g_i^*) = 1 \qquad (9.11)$$

$$u_i(g_{i^*}) = 0 \quad \forall\ i \qquad (9.12)$$

$$\sigma^+(a) \geq 0 \text{,} \quad \sigma^-(a) \geq 0 \quad \forall a \in A' \qquad (9.14)$$

$$u_i(g_i^j) \geq 0 \quad \forall i, \forall j \qquad (9.15)$$

where Eq. (9.6) is used to calculate the utilities of the g_i (a) between two consecutive bounds. This is the basic UTA-UTASTAR model that we shall use. The interested reader may find a few other specifications as well as a set of comparative simulations in Beuthe and Scannella (1996, 2001). Some of these specifications include additional constraints for handling additional information that may be given by the decision maker.

The program above may have two types of solution: either all errors have zero values and $F = 0$, or some errors are positive and $F > 0$. In this second case, there does not exist a non-linear additive utility function that perfectly represents the preferences expressed by the decision maker. If we exclude the cases of a decision maker not able to reasonably compare projects, or irrational in the sense of exhibiting intransitive preferences, the presence of errors may indicate that the decision maker preferences are characterised by partial utilities which are not independent of each other or which are not monotonically increasing. But, it may also be the case, more simply, that the intervals chosen should have been more numerous or defined in a different way.

The specification of an additive function and its derivation from separate assessments of partial function supposes an assumption of preferential independence. Its means that, if two projects are characterised by the same values for some criteria, the preferences between them depend only on the values taken by the other criteria. How much this hypothesis is acceptable in practical applications may vary from case to case. Von Winterfeldt and Edwards (1973) are of the opinion that an additive function could be used as a good approximation. Indeed an additive function of non-linear partial utility functions is quite a flexible specification, and it can provide an estimation that implicitly takes into account a certain degree of interdependence among criteria. Stewart (1995) empirically demonstrated that it was indeed a robust specification. Furthermore, through a set of simulations, Beuthe and Scannella (2001) showed that the UTA model is quite able to obtain useful results with F equal or close to 0, even in case of interdependence between criteria.

Whether F equals zero or not, the program's solution may not be unique, as it is often the case in linear programming. This problem must then be solved by a post-optimality analysis. Jacquet-Lagrèze and Siskos (1978) have simply proposed to use a function which is the average of the extreme optimal functions obtained from a sensitivity analysis applied on the last bounds of each criterion.

This sensitivity analysis is made with an additional constraint

$$\sum_{a\in A'}\sigma(a) \leq F^{*} + \theta\,, \qquad (9.16)$$

where θ is a small positive number. This procedure was shown to provide a practical and efficient method of estimation.

4 Preliminary Results of the Multi-criteria Analysis

This section will illustrate this multi-criteria methodology and the nature of its results with an application to a set of individual preference observations. This task was performed with the MUSTARD software (Scannella 2001; Scannella and Beuthe 2001, 2002). To begin with, the first line of Table 9.2 gives the average weights computed over the 98 firms that we have already interviewed. They clearly show that transport cost is the most important factor, followed by reliability but with a much lower weight.

The following lines of Table 9.2 give the individual results of nine firms from various industrial sectors. Again the importance of the cost appears quite clearly, as cost is the main factor in seven out of nine cases. Reliability comes next but often receives a very small weight. The other factors take some importance in a few cases according to the particular circumstances of transport; otherwise, they receive small weights. For instance, transport time is important for the textile firm and the producer of electronics, which ship over rather long distances. For these two firms, as well as for the pharmaceutical firm, cost appears less important and the weights are more equally distributed. Reliability is the first factor for the pharmaceutical firm, which also gives a high weight to an absence of losses. This last factor also has some importance for one of the steel making firm that ships by waterway.

It is worth underlining though that these results do not mean that the non-cost quality attributes taken together do not play an important role in decision making. Indeed, together they weight about as much as the cost. This question certainly deserves additional probing.

These results and comments are just descriptive of a few particular situations. Nevertheless, it is clear that there is much heterogeneity in the results; this could be expected as these firms are very different with respect to their products and spatial situation. A rigorous analysis of possible explanatory factors can only be performed on a sample or groups of firms and with the help of appropriate econometric techniques. When the survey is completed, the results obtained for the full sample with this multi-criteria method will be analysed in order to identify additional explanatory variables.

Table 2. Relative weights of attributes

Firms	Freq.	Time	Reliab.	Flex.	Loss	Cost	Σ errors	Kendall
Average weights 94 firms	.069	.068	.170	.065	.097	.532	-	-
Steel, multimodal 991 km, 240 hours C:.038, S: 350	.008	.029	.115	.042	.084	.722	.009	.978
Steel, waterway 404 km, 55 hours C:.017, S: 900	.003	.008	.001	.004	.327	.658	.345	.947
Textile, multimodal 2104 km, 120 hours C:.11, S: 15	.081	.267	.145	.060	.146	.301	.163	.933
Electronic, road 800 km, 48 hours C: .12, S: 23	.174	.360	.139	.069	.043	.215	.225	.962
Chemical, Rail 1200 km, 48 hours C: .002, S: 28	.003	0	.001	.004	.001	.983	.011	.909
Cement, road 123 km, 3 hours C: .25, S: 31.5	.001	.001	.011	.002	0	.985	.021	.945
Packing, road 500 km, 10 hours C: .16, S: 12	.003	0	.092	.002	.001	.902	.011	.978
Pharmaceutical, road 240 km, 24 hours C: .96, S: .1	.076	.045	.358	.127	.187	.207	.409	.930
Building mat., waterway 155 km, 48 hours C: .025, S: 1000	0	0	.167	0	0	.833	0	1

C Euro cost per tonne/km, *S* shipment size in tonne.

Also, it will be necessary to compare these results with those obtained by other methods. At this point, we can already mention that a set of experiments were made with classical statistical conjoint analyses that provided similar results: the cost factor again was the most important, albeit with a lower weight, and reliability came second. However, given our experimental design of 25 alternatives, conjoint analyses consume too many degrees of freedom in individual preference estimations. Furthermore, they do not incorporate a minimal rationality specification like monotone increasing partial utility functions. Hence, we abandoned that methodology, which did not obtain reliable results[4]. Another current experiment with a frontier analysis of transport market also confirms that none of the non-cost attributes plays a significant role in the decision-making.

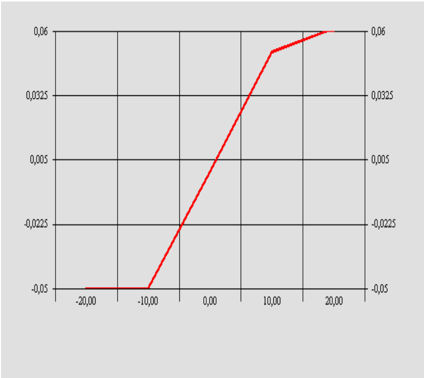
[4] For more details: Bouffioux and Beuthe (2004).

Obviously, a larger sample will also allow the use of some discrete choice models like the usual probit and logit models.
Meantime, it is still interesting to further analyse a particular case, in order to illustrate the potential of this multi-criteria methodology for assessing the qualitative factors' equivalent money value. Let us take the case of the steel making plant using a multi-modal solution (barge, rail, truck) for transporting coils towards Italy over a distance of 991 km. As can be seen in Table 9.2, the estimated weights of the additive decision function are: 0.008 for Frequency, 0.029 for Time, 0.115 for Reliability, 0.042 for Flexibility, 0.084 for Loss and 0.722 for Cost. Five alternatives were deemed preferable to the status quo solution, and, in the last part of the questionnaire, the decision maker expressed the intention of switching mode if they would be available.
As explained above, the UTA model permits the estimation of non-linear functions made of a number of linear segments. The following Fig. 9.1 illustrates the partial utility functions estimated by MUSTARD for the various attributes but one, i.e. frequency. In effect, this particular attribute with a negligible weight had an entirely flat partial function; it is not useful to show it. To well understand these graphs, note that:

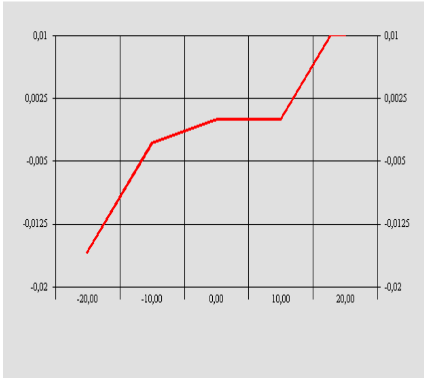
- The abscissa scale for the attributes is centred around the status quo value of a zero percentage of variation.
- For the Time, Loss and Cost attributes, the abscissas have been defined in negative percentage of increase, so that a higher level on the scale corresponds to a more favourable level. Hence, these attributes are indicated as time saving, absence of loss and saving of cost, respectively, and their utilities are increasing along the scale of variation.
- The utilities are scaled with respect to a zero utility level at the status quo point where there is a 0% variation.

The presentation of the functions on similar size graphs should not lead us to forget the small weights affecting some of these attributes, which hardly play any specific role in actual decision making.
An attractive feature of this non-linear methodology is that it allows the computation of different money equivalent values for an increase and a decrease of an attribute from the status quo level, i.e. different willingness to pay and willingness to accept compensation. For example, the steel making plant would appear ready to pay an additional .07 EURO per tonne for a gain of one day over the present time of ten days, but would demand a compensation, or a reduction, of 2 EURO for a one day increase in transport time. Furthermore, for a one percent improvement in reliability the firm would be ready to pay .08 EURO more per tonne, whereas a one percent loss in reliability would justify a reduction of 1.7 EURO per tonne[5].

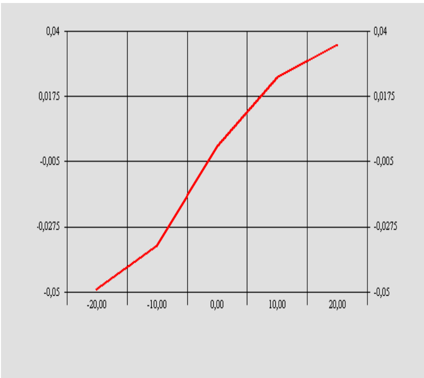
[5] For this computation of equivalent money values, the relevant trade-off's were computed over the variations from 0% to +20% and from –20 % to 0%. Shorter variation intervals would have lead to smaller differences between the two willingness.



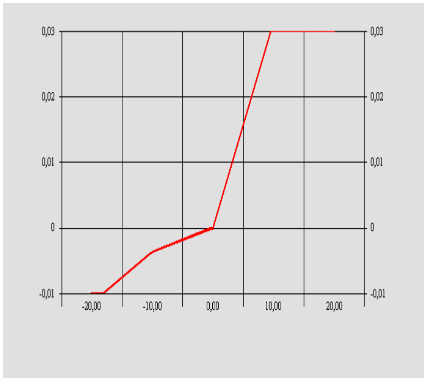
Reliability variation in % (weight: .114)



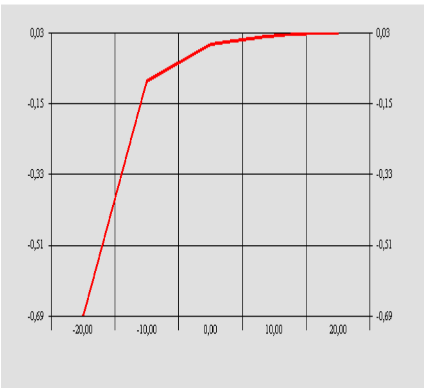
Time saving variation in % (weight: .029)



Flexibility variation in % (weight: .043)



Absence of loss variation in % (weight: .084)



Cost saving in % (weight: .722)

Fig 1. Partial utility functions

These differences indicate that this firm is well adjusted to the option it chose. A shorter transport time or a higher service reliability obviously would be valued to a certain degree, but a longer transport time or a lesser reliability definitely would cause problem. These different valuations mainly result from the concave partial utility function of the inverted cost attribute. For the carriers it means that they should strive to maintain their performance at the expected level, since a degradation of the service level would seriously affect their client and could induce a switch of carrier in this case, unless they can propose a substantially lower tariff. This type of result deserves additional scrutiny over the full sample.

5 Conclusion

This is research in progress, and it is too early to draw definite conclusions on the use of this methodology. Let us tentatively state that, this multi-criteria tool provides some interesting insight on the preferences decision makers and aids in the ordering of stated preferences through the levels of the Kendall coefficient and errors. It also provides equivalent money values of the willingness to pay and the willingness to accept compensation. Obviously, with a large sample, the basic weights and the equivalent money values could be averaged over relevant sub-groups of firms to provide a more general view of the role transport attributes play in influencing choices. This method also provides global money equivalent value for each alternative. Such estimates could be input to econometric modelling. Further research would permit us to compare the results of this methodology with those that can be obtained with the more usual logistic models.
Provisionally, we can conclude that the cost factor weight varies heavily and the qualitative attributes also play an important role, despite the fact that they weight little when considered separately. This raises an interesting issue about the modelling of the qualitative differences between transport modes, i.e. whether a simpler analysis with an aggregate measure of quality would be worth considering. However, it is important to note that the importance given by transport managers to the various attributes could vary with transport circumstances and industrial activity. This feature would complicate the derivation of a common measure of quality.

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TOTAL LOGISTICS COST AND QUALITY ATTRIBUTES OF FREIGHT TRANSPORTATION

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Abstract

The organisation of a firm's transport is approached from a total logistic cost point of view that includes the full chain of transport operations from the shipping firm to the consignee. Thus, this paper analyses not only the full transport costs (transport and handling), but also the ordering and administrative costs, as well as the various costs of inventory (in-transit, cycle and safety). The relationship between these elements and the quality attributes of transport means is analysed. These are identified as the frequency of service, transport time, reliability, the carrier's flexibility of response, and the absence of damages and losses. The total logistic cost of a transport flow is minimized with respect to these attributes and the shipment size. The optimal conditions allow to derive a set of marginal value relationships between the cost of transport and the above quality attributes. They provide a framework of interpretation for an analysis of the role played by quality attributes in the decision of a transport means choice.

Keywords: Freight transport, Logistic costs, service quality
Topic Area: B3 Logistics, Freight and Fleet Management

1. Introduction[1]

The general organisation of a firm's transport must be approached from a business logistics point of view, which analyses " the movement, storage and related activities between the place of origin where the company obtains its raw materials, and the place where its products are required for consumption by its customers (Blauwens *et al.*, 2002). In some cases, this may lead to an analysis of the production process of the shipping firm or of the consignee. Actually, the total logistics approach is in principle concerned with the whole chain of productive activities including transport. While acknowledging this very comprehensive view, the present paper must nevertheless limit somewhat its scope to an analysis of transport operations as they may directly influence some elements of the firms' costs structure and determine the choice of a mode or means of transport. Actually, we only analyse this problem at the level of a specific freight transport flow between an origin and a destination. Thus, beyond the usual freight transportation and handling costs, this paper focuses on the impacts of transport operations on the ordering and

[1] This paper is one preliminary output of a research led by a Belgian consortium directed by M.Beuthe (Catholic University of Mons), H.Meersman and E.Van de Voorde (University of Antwerp), M. Mouchart (Catholic University of Louvain), and F.Witlox (University of Ghent). We thank the Belgian Federal Office for Scientific, Technical and Cultural Affairs (OSTC) for the financial support it granted to this project

administrative costs, and on the costs of the different types of inventory stocks related to a specific freight flow.

This wider scope of analysis necessarily leads to an investigation of the role played by the qualitative attributes of transport services: their frequency, time of transport, reliability, flexibility of response by the carrier, and absence of damages. These attributes certainly matter for the transport manager as they affect the transport chain and the management of inventory stocks. Hence, it is important to analyse the role they play in the choice of a means of transport.

On the basis of the literature on transport total logistic cost, the paper first formulates a set of analytical cost functions of the shipment size of a freight flow, its total volume, and the above quality attributes. In a second section, a minimization of the total logistic cost provides a set of optimal conditions that allow the derivation of marginal value relations for the qualitative attributes, and provide a theoretical interpretation framework for their implicit values. The last section discusses estimation strategies which could be applied to the data of a transport managers survey on transports' quality of service that a consortium of Belgian universities is about to complete. Using a UTA type of multi-criteria analysis, it also presents a few illustrative examples of estimates of the quality attributes importance in the decision process.

2. The logistic costs

a) Transportation costs : These are the charges paid to the carrier or incurred by the shipping firm if it uses its own vehicles and personnel. Transport costs are function of the mode used, the volume of the flow and the size of the shipments. The rates that are paid are function of the market organisation. While, road and inland waterway transport rates are likely to be close to cost, because of the competitive structure of these modes, railway rates are better controlled by the railways which can discriminate among their clients according to their location and what transport alternatives they may have. Focussing on the relationship between cost, on the one hand, and shipment size and volume, on the other hand, we can write the transport unit cost function (cost or rate according to the situation) as: $R = R(q, Q, Z)$, where q is the shipment size, Q the total of shipments over a year, and Z is the vector of transport mode (or means) characteristics, i.e. its reliability (G), safety (S), time of transport (T), frequency (D), and flexibility (F).

b) Freight handling costs : The costs of loading, unloading, and transhipments can be sizable. They may play an important role for the choice of a transport solution, when comparing direct road transport to waterway or railway transports, which often involve some trucking in inter-modal or multi-modal solutions. The total handling cost for a particular transport solution can written as $h(Z, q). Q$, since it varies with the transport characteristics and shipment size.

c) Ordering cost : The cost of order processing and administration can be taken as proportional to the number of orders. Hence it can be written as: $a(Z).Q/q$, in case it varies with the transport characteristics.

d) Inventory costs : These costs are composed of several elements, mainly, the cost of the cycle stock, the one of the in-transit inventory, and the cost of the safety stock (Baumol and Vinod, 1970). Seasonal demand and speculation may also justify some stocking of goods, but they will not be considered here as we want to focus on elements that play a role in a relatively stable economic environment.

1° <u>Cycle stock</u> : With the exception of Just-in-Time delivery systems, most companies order goods in a quantity that satisfies their needs for a certain period. Hence, stocks are bound to exist with a cyclical pattern, since they build up at the consignments arrival and diminish progressively until the arrival time of the next consignment. In case the stock of a particular good is consumed at an even pace, the level of its stock will have take the shape of a series of rectangular triangle next to each other, and its average level will be equal to half the size of one consignment. Hence, the cycle stock cost is $Ic = ½.w.q$, where w is the yearly inventory cost per unit. The inventory cost takes into account the unit value of the good, the rate of interest on the capital embedded in the stock, and all the other costs associated with the stock operations (insurance, warehousing, etc.). It is obvious that the smaller the size of the consignment q, the smaller is the cycle stock cost for the consignee.

2° In-transit inventory: Goods are also in inventory during transportation, and there is a similar cost attached to that inventory on wheels. This cost again depends on the consignments' value, the rate of interest and insurance cost, the total volume shipped, and the duration of transport. For a particular transport solution, it can be written as $It = v. T. Q$, where v is the inventory cost per unit of time and T is the average transport duration (in fractions of a year).

3° Safety stock : Even though we assume a rather stable economic environment, there remains some uncertainty linked to the irregular level of demand from day to day and possible delivery delays of the goods. Hence, it is necessary to keep some additional stock beyond what is normally needed to meet the average rate of stock consumption. Besides the marketing policy adopted by the consignee, the safety stock level is mainly a function of the transport mode characteristics Z. Like the cost of cycle stock, the cost of the safety stock depends on the value of the good, the rate of interest and insurance. It depends also on the Z characteristics of the transport, i.e. reliability, safety, frequency, flexibility and time of transport.

This cost can be estimated as $Is = w \,.\, k \,.\sigma(q, Z)$, where

$\sigma = (L(Z).\sigma_q^{\,2} + q^2.\sigma_L^{\,2})^{1/2}$ is the standard deviation of demand during lead time L, assuming that demand and lead time are independent of each other (Fetter and Dalleck, 1961; Ballou, 1999)[2]

$\sigma_q^{\,2}$ is the variance of demand;

$\sigma_L^{\,2}$ is the variance of lead time;

$L(Z)$ is the average lead time in 1/m fractions of year, a function of Z; it is counted from the moment an order is placed until its delivery and includes transportation time;

q, the consignment size, is also the average demand for a 1/m fraction of year ($qm=Q$);

k is a parameter depending on the probability of running out of stock that a firm is ready to accept;

w is the yearly inventory cost, as above.

The variance of demand is outside the control of the firm, whereas the lead time and its variance depends upon Z. Hence, the writing of the standard deviation as a function of q and Z. We can postulate that σ and the safety stock increases with the lead time L, and decreases with increasing reliability, safety, flexibility and frequency of transport service.

The parameter k is a measure of the willingness to accept a stock-out. It is a somewhat subjective parameter that must be decided by each firm and depends on the type of good and

[2] Under the hypothesis that the lead time is distributed according to a Poisson distribution, σ can be estimated as $\sigma = ((1/m + t)\ q.m)^{1/2}$ (Hadley and Whitin, 1963; Baumol and Vinod, 1970)), where $(1/m + t)\ q.m$ is an estimate of the unsatisfied demand that may accumulate during the period $(1/m + t)$ of maximum lead time, $1/m$ being the time between two shipments, i.e. the delay, additional to the transport time t, when an order is just missing a shipment. Different assumptions lead to other specifications of σ, which are reviewed in Vernimmen and Witlox (2001).

adopted marketing strategy. In a specific firm logistic analysis, it can be chosen on the basis of a reasonable assumption, or estimation, of the probability distributions of demand and lead time. Assuming a normal distribution, k is then the critical value at which the area under the standard normal curve at the right of k equals the accepted risk of running out of stock. For instance, k = 2.33 for a 1% risk of running out of stock, and k = 1.64 for a 5% risk.

The parameters v and w depend on the money value of the goods. Hence, they vary from one firm to another, like the standard deviation σ, which depends on the demand and lead time variances.

Note that only the cycle and safety costs of the consignee are considered in this analysis since it is focused on a particular flow of goods towards one consignee. The management of the overall stock by the producer of a good would require an altogether more global analysis. In the present context, it is supposed to be a given, which may constraint the transport solution. Also, it is assumed that essentially all impacts of a particular transport flow on the consignee's production cost are taken into account through the various inventory costs, and particularly through the parameters k and σ of the safety stock function . It follows that the total logistic cost, for the period during which the total flow is Q, can be written as the sum:

$$C = R(q, Q, Z).Q + h(Z, q).\ Q + a(Z).\ Q/q + \tfrac{1}{2}\, w.\ q + v.\ T.\ Q + w.\ k.\ \sigma(q, Z), \text{ or} \qquad (1)$$

$$C(q, Q, Z) = E(q, Q, Z) + I(q, Q, Z),$$

where, $E(q, Q, Z) = R(q, Q, Z).Q + h(Z, q).\ Q$, and

$$I(q, Q, Z) = a(Z).\ Q/q + \tfrac{1}{2}\, w.\ q + v.\ T.\ Q + w.\ k.\ \sigma(q, Z).$$

In this formulation, the function $E(q, Q, Z)$ corresponds to what could be called the external part of the logistic cost determined by the transport supply side, i.e. the carrier, even in the case where the transport operation is not outsourced. In contrast, the function $I(q, Q, Z)$ corresponds to the internal logistic cost of the shipper and/or consignee[3].

As an example, Table 1, drawn from a firm's case-study by Vernimmen and Witlox (2001), gives the values taken by some of the variables and parameters in equation (1).

[3] For lack of a better terminology. Indeed part of the handling cost may include an internal component, like the loading/unloading operation at origin or destination.

Table 1: Example of logistic costs

	Road haulage	Inland navigation
R (€ / tonne)	10.91	8.43
w (€ / tonne)	93	93
t (days)	0.19	4.48
v (€ / tonne/day)	0.26	0.26
q (tonnes)	25	1200
$k.\ \sigma$ (tonnes)	250	1214
Transport cost/ tonne	10.91	8.43
In-transit inventory cost/ tonne	0.05	1.14
Cycle stock cost / tonne	0.02	1.01
Safety stock cost / tonne	0.18	0.89
Additional fixed cost / tonne[1]	0.09	0.45
Total logistics cost / tonne	11.25	11.92

Source: Vernimmen and Witlox (2001).
[1] Costs that do not vary with the stock level (unloading quay and equipment, warehouse insurance).

3. Optimal conditions for minimum transport logistic cost

Assuming continuous functions, the first order conditions for a minimum of the total total logistic cost $C(q, Q, Z)$, given a total flow Q, are

$$\partial C/\partial q = Q.\partial R/\partial q - a.Q.q^{-2} + Q.\partial h/\partial q + ½\ w + w.\ k.\ \partial \sigma/\partial q = 0, \qquad (2)$$

$$\partial C/\partial Z_i = Q.\partial R/\partial Z_i + Q.\partial h/\partial Z_i + Q.q^{-1}.\partial a/\partial Z_i + w.\ k.\ \partial \sigma/\partial Z_i = 0,\ \text{for } Z_i \neq T, \qquad (3)$$

$$\partial C/\partial T = Q.\partial R/\partial T + Q.\partial h/\partial T + Q.q^{-1}.\partial a/\partial T + v.\ Q + w.\ k.\ \partial \sigma/\partial T = 0. \qquad (4)$$

We can assume here that the second order conditions also are satisfied.

From equation (2), the optimal “economic order quantity” q^* can be deduced:

$$q^* = [\ a.\ Q.\ (Q.\partial R/\partial q + Q.\partial h/\partial q + ½\ w + w.\ k.\ \partial\sigma/\partial q)^{-1}\ ]^{1/2}, \qquad (5)$$

which is similar to the usual expressions found in the literature (Blumenfeld, 2001), even though it is adapted to the current context.

From equations (3) and (4), the marginal value of the transport characteristics can be shown as:

$$\partial R/\partial Z_i + \partial h/\partial Z_i = -(q^{-1}.\partial a/\partial Z_i + w.\ k.\ Q^{-1}.\partial \sigma/\partial Z_i), \quad \text{for } Z_i \neq T, \qquad (6)$$

$$\partial R/\partial T + \partial h/\partial T = -(q^{-1}.\partial a/\partial T. + v + w.\ k.\ Q^{-1}.\partial \sigma/\partial T). \qquad (7)$$

Indeed, (6) and (7) equate a characteristic’s marginal cost paid by the shipper to its internal marginal cost. For a characteristic like reliability, for example, equation (6) shows that its internal value is linked to its impacts on the ordering cost and safety stock, whereas equation (7) shows that the value of transport time also depends on its impact on the in-transit inventory.

It is worth pointing out that the conditions of logistic optimality, equations (2) to (3), suppose that the variables are continuous. For a given choice of a transport mode, that may approximately be the case, since several levels of service are indeed proposed by carriers. However, there are strong discontinuities from one mode to another, so that carriers may not be able to supply the desirable levels of some transport services. To give obvious examples, the transport time of each mode can only vary within a limited range for technical and structural reasons, and available vehicles' carrying capacity may not be appropriate to transport a given optimal shipment size *q*. It follows that the choice of a transport solution is constrained by the set of available alternatives, hence, that there is no guarantee that a shipper (or consignee) can reach a solution that strictly would satisfy the optimal logistic conditions. Actually, in most cases, the analysis of a best logistic solution, including the choice of a mode, has to focus on the valuation of the total logistic cost function and the comparison of values it takes for a discrete set of available solutions. For doing so in a rigorous analysis at the firm's level, all the logistic cost components for each solution should be estimated by the firms, in particular *v, w, k, L*, and the two variances σ_q^2 and $\sigma_L^{\ 2}$.

In Section 1, a number of qualitative attributes of transport service have been identified, which determine to a large extent the total transport logistic costs. They are the reliability (*G*), safety (*S*), flexibility (*F*), time of transport (*T*) and frequency of service(*D*). They obviously play an important role in the choice of a transport solution, and particularly in the choice of a mode. From the definition of total logistic cost and the discussion above, it is clear that the willingness to pay for a quality level of transport service depends on its impact on the internal logistic cost *I*(*q, Q, Z*). Thus, rather than trying to estimate each of the parameters in (1), an alternative approach is to analyse directly the relative importance for the shipper of the "external cost" *E* in comparison with the relative importance of each qualitative factor in the "internal logistic cost".

Assuming again continuity for expository convenience, we can presume that the ordering cost is not likely to vary with the reliability, safety and time attributes, so that this specific cost can be written as $a(F, D).\ Q.\ q^{-1}$. From the right-hand-side of equations (6) and (7), it follows then that :

$$\partial I/\partial G\ .\ Q^{-1} = w.\ k.\ Q^{-1}.\ \partial\sigma/\partial G\ ,$$
$$\partial I/\partial S\ .\ Q^{-1} = w.\ k.\ Q^{-1}.\ \partial\sigma/\partial S,$$
$$\partial I/\partial T\ .\ Q^{-1} = v + w.\ k.Q^{-1}.\ \partial\sigma/\partial T,$$
$$\partial I/\partial F\ .\ Q^{-1} = q^{-1}\ .\partial a/\partial F + w.\ k.\ Q^{-1}.\partial\sigma/\partial F,$$
$$\partial I/\partial D\ .Q^{-1} = q^{-1}.\ \partial a/\partial D + w.\ k.Q^{-1}.\ \partial\sigma/\partial D. \qquad (9)$$

These equations provide a theoretical interpretation of the firms' willingness to pay per unit for an attribute (small) variation around a given transport solution. They suggest that the safety stock factor could play a more important role in the transport choice decision than the other attributes. Note that all the derivatives in (8), except the one with respect to T, should take a negative value, because ordering cost could only decrease with an improved carrier's flexibility and higher frequency, while the standard deviation should also decrease with more favourable levels of quality attributes.

Other assumptions about the inclusion/exclusion of qualitative attributes in the various functions could very well be made that would simplify this set of equations (8), but, like the above assumption, they should be the object of empirical verification whenever possible.

4. Research in progress: Estimation methodology

As suggested above, a technical analysis of specific cases could provide estimation of the parameters of the logistic functions, at least for these cases. This is an effort we pursue at the present time.

Beyond this approach, there are essentially two ways to estimate the value of these partial derivatives or their discrete equivalents. Firstly, we can observe the chosen transport solutions and analyse directly their relationship with the cost of transport and its reliability, flexibility, safety, time and frequency of service. This can be done through various techniques of regression analysis, like multinomial logit and probit analyses that estimate linear decision functions, the coefficients of which can be used to value transport attributes in money equivalent. This type of analysis is usually performed at the aggregate level of a sample of firms. With a consortium of Belgian universities (Universities of Antwerp, Gent, Mons and Louvain-La-Neuve), we are currently completing a survey of Belgian transport managers that should provide enough information to perform such analyses.

Another approach, at the level of individual firm, can be considered if enough information about the firm's preferences is provided by interviews organised along the line of Stated Preference methodology. Actually, the survey mentioned above is organised around a Stated Preference questionnaire that proposes hypothetical transport solutions the transport manager must rank according to his/her preferences. This information can then be used as an input in a variety of regression models, but it can also be analysed with techniques of multi-criteria decision analysis. This approach at the individual firm level should prove itself particularly useful if it is also applied in the context of case studies, so that comparison could be made between values obtained from technical analyses and those obtained from surveys and econometric estimations. However interesting, such a comparative work could turn out to be rather difficult, since both revealed and stated preference analyses could include additional subjective factors that may influence transport decisions; moreover, stated preferences can only relate to intentions rather than to real decisions.

This is still a research in progress, and we cannot as yet propose any comparison between the different methods. However, borrowing from a previous paper (Beuthe et al., 2003), we can provide some results obtained from a UTA multi-criteria analysis applied to stated preference data of a sample of firms. They indicate that, after the most important direct cost of transportation (i.e. the external cost), it is the reliability and, in some cases the time, that appear relevant for the transport manager. Reliability certainly must be the factor that influences the most the level of the safety stock.

In our on-going survey, 25 hypothetical transport solutions are proposed to transport managers who must rank them according to their preferences. The transport alternatives are defined by the levels of six transport attributes: Frequency of service, Time of transport, Reliability, Flexibility, Absence of damages, and Cost. Both Time and Cost includes all the loading and unloading operations. The level of attributes in the different alternatives is defined in percentage with respect to the present situation. The design of the transport alternatives is such that it makes up an orthogonal matrix.

The UTA multi-criteria model evaluates an additive "utility" function of the attributes on the basis of rank ordered preferences among alternatives. It is set as a goal programming model, which estimates for each criteria a set of partial utility values that allow the derivation of piecewise non-linear functions made of successive linear segments. In the present case, the task was performed with the MUSTARD software (Scannella, 2001, Scannella and Beuthe, 2001 and 2002).

The first line of the following Table gives the average weights computed over the 98 firms that we have already interviewed. They clearly show that transport cost is the most important factor, followed by reliability but with a much lower weight. The Table also gives the individual results of nine firms chosen from different industrial sectors. Again the importance of the cost appears quite clearly, as it is the main factor in seven out of nine cases. Reliability comes next but often receives a small weight. The other factors take some importance in a few cases according to the particular circumstances of transport; otherwise, they receive small weights. For instance, transport time is important for the textile firm and the producer of electronics, which ship over rather long distances. For these two firms, as well as for the pharmaceutical firm, cost appears less important and the weights are more equally distributed. Reliability is the first factor for the pharmaceutical firm, which also gives a high weight to an absence of losses. This last factor also has some importance for one of the steel making firm that ships by waterway. It is worth underlining though that these results do not mean that the non-cost quality attributes taken together do not play an important role in decision making. Indeed, together they weight about as much as the cost. This question certainly deserves additional probing.

These results and comments are just descriptive of a few particular situations. Nevertheless, they indicate that there is much heterogeneity in the results. This could be expected as these firms are very different with respect to their products and spatial situation. A rigorous analysis of possible explanatory factors can only be performed on a sample or groups of firms and with the help of appropriate econometric techniques. This will be done when the survey is completed.

Firms	Freq.	Time	Reliab.	Flex.	Loss	Cost	Σ errors	Kendall
1. Average weights 94 firms	**.069**	**.068**	**.170**	**.065**	**.097**	**.532**	**-**	**-**
Steel, multimodal 991 km, 240 hours C:.038, S: 350	**.008**	**.029**	**.115**	**.042**	**.084**	**.722**	**.009**	**.978**
Steel, waterway 404 km, 55 hours, C:.017, S: 900	**.003**	**.008**	**.001**	**.004**	**.327**	**.658**	**.345**	**.947**
Textile, multimodal, 2104 km, 120 hours, C:.11, S: 15	**.081**	**.267**	**.145**	**.060**	**.146**	**.301**	**.163**	**.933**
Electronic, road 800 km, 48 hours, C: .12, S: 23	**.174**	**.360**	**.139**	**.069**	**.043**	**.215**	**.225**	**.962**
Chemical, Rail 1200 km, 48 hours, C: .002, S: 28	**.003**	**0**	**.001**	**.004**	**.001**	**.983**	**.011**	**.909**
Cement, road 123 km, 3 hours, C: .25, S: 31.5	**.001**	**.001**	**.011**	**.002**	**0**	**.985**	**..021**	**.945**
Packing, road 500 km, 10 hours, C: .16, S: 12	**.003**	**0**	**.092**	**.002**	**.001**	**.902**	**.011**	**.978**
Pharmaceutical, road 240 km, 24 hours, C: .96, S: .1	**.076**	**.045**	**.358**	**.127**	**.187**	**.207**	**.409**	**.930**
Building mat., waterway 155 km, 48 hours C: .025, S: 1000	**0**	**0**	**.167**	**0**	**0**	**.833**	**0**	**1**

Note: C is the Euro cost per tonne/km; S is the shipment size in tonne.

Source: Beuthe et al., 2003.

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A comparison of Conjoint, Multi-criteria and Conditional logit analyses for rank ordered data

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1 Introduction

This paper analyses the preference rankings of nine transport managers between 25 freight transport alternatives. The latter are defined by the levels taken by six attributes: Frequency of services, the Time taken by door-to-door transportation, the Reliability with respect to delivery time, the carrier's Flexibility of response to unscheduled demands, the level of value Losses during transportation, and the transport Cost. The rankings were gathered through in-depth individual interviews of a number of managers, realised by a research team made of researchers from four Belgian universities (FUCAM, RUG, UA and UCL). Before pursuing an econometric analysis at an aggregate sample level, nine cases were selected for a more detailed analysis at the individual level, in order to obtain some insight into the ranking process by the managers, and to test some quantitative models of decision making.

Three methods are compared: conjoint analysis often used in a marketing context to derive the utilities associated to goods or services' attributes, two multi-criteria analyses that are usually applied to assess projects characterized by a set of impacts, and two rank-ordered logit models in line with the classical discrete utility models. Each model allows the computation of a manager additive utility function, as well as the partial utilities associated with each attribute.

The specification of an additive function supposes an assumption of preferential independence. Its means that, if two alternatives are characterised by the same values for some criteria, the preferences between them depend only on the values taken by the other criteria. How much this hypothesis is acceptable in practical applications may vary from case to case. von Winterfeldt and Edwards (1973) are of the opinion that an additive function could be used as a good approximation. Indeed an additive function of non-linear partial utility functions is quite a flexible specification, and can provide an estimation that implicitly takes into account a certain degree of interdependence among criteria. Stewart (1995) empirically demonstrated that it was indeed a robust specification. Through a set of simulations, Beuthe and Scannella (2001) also have shown that it could provide useful results even in case of interdependence between criteria.

The estimated conjoint analysis model, which was selected for reasons detailed in Section 2, is a simple metric one. It corresponds to a linear regression of the ranks on the six attributes, each discrete level of attributes receiving a specific coefficient. The multi-criteria models are of the goal-programming variety, the UTA model of Jacquet-Lagrèze and Siskos (1978, 1982) and the Quasi-UTA model of Scannella (2001), which are specifically devised for analysing preference rankings. The rank-ordered logit model is the one suggested by Luce and Suppes (1965) and implemented by Beggs et al. (1981) and Chapman and Staelin (1982). It carefully models the successive probabilities of the choices made in ranking with respect to less preferred alternatives. The second discrete choice model is a nested version of the rank-ordered logit, which tries to reproduce the two-steps ranking process suggested to the managers: first partition the set of alternatives in three different preference sets, then rank inside each set.

The "utility function" terminology is maintained throughout the paper for convenience rather than for substance. Actually, a more neutral terminology like "decision function" or "value function" could be more appropriate. Indeed, it is not obvious that a competent transport manager thinks in terms of maximizing a utility value. They likely rather try to minimize some measure of the total transport logistic cost that integrates many internal and external logistic factors. These factors are functions of the transport attributes, and may naturally include some subjective judgment as to risk taking, since it bears upon the management of safety stocks.

Beyond this introduction, Section 2 briefly reviews conjoint analysis models and, presents two simple models that are the only available options in our circumstances. Section 3 explains the UTA-type multi-criteria models, and compare them to the conjoint analysis approach. Section 4 sets up the rank-ordered logit methodology and its nested version. Section 5 presents and compares the results obtained from the various estimated models. Some final comments conclude the paper.

2 Conjoint Analysis (CA)

Conjoint analysis is based on the premise that individuals value a product or service by combining the values provided by their attributes or characteristics, which are assumed to be the source of a consumer's utility (Lancaster (1966, 1971)). It is an analysis-of-variance model of the attributes' main effects, i.e. of their direct contributions to the service's global value. It can be shown to be equivalent to a regression analysis of an index of preference on the measured levels of attributes. This approach is much used in marketing surveys to analyse observed or stated consumers' preferences towards goods or services with different characteristics. The dependent variable is usually a rating on an ordinal scale of measurement that translates preferences, whereas the independent variables are often nominal and sometimes interval-scaled variables. Then, conjoint analysis (CA) decomposes the judgment preferences data into components corresponding to the attributes of the alternative goods or services. There are two types of conjoint analysis: metric and non-metric. Metric CA is applied when the respondents' ratings, expressing strengths of preference for a service, are directly used as dependent variable to be regressed on the services' characteristics. A non-metric CA allows for monotonic transformations of the ratings that best fit the data. The latter approach may be of interest when rankings are only available, in place of ratings. Indeed, a ranking does not normally correspond to a scaled utility since the difference of utility between ranks, say, 25 and 24 can be different from that between 24 and 23. The only information given by a ranking is that alternative 24 is preferred to 25, as 1 is preferred to 2 and so on. Non-metric CA may then be useful for transforming rankings into ratings expressing the possible different strengths of preference between services.

For convenience, conjoint analysis is presented here as a regression analysis. In the case of a metric CA, the dependent variable, either a rating or ranking is represented by the vector y, each element of which is defined with respect to a specific service's attributes. The independent variables (attributes or factors) are represented by the matrix X. In the following equation (1), which applies to a case of six attributes, y_{ijklmn} is one element of y and its six indices indicate the level taken by each attribute. Hence, it is seen that a specific β coefficient is associated with each specific value taken by an attribute, which may lead to a large number of independent variables. The partial utility value contributed by each attribute' level, or part-worth utilities, are given by the products βx's that appear in equation (1). Usually, the partial utility levels of an attribute are normalised to a zero sum.

$$y_{ijklmn} = \mu + \beta_{1i}x_{1i} + \beta_{2j}x_{2j} + \beta_{3k}x_{3k} + \beta_{4l}x_{4l} + \beta_{5m}x_{5m} + \beta_{6n}x_{6n} + \epsilon_{ijklmn} \quad (1)$$

The data analysed in this paper are rankings of 25 transport alternatives. These are defined by six attributes: transport Time, Frequency of service, Reliability of delivery, carrier's Flexibility, transport Safety and transport Cost. The definition of these will be given in Section 5 on estimation results. Each attribute can take five levels. This means that there are 25 parameters to estimate for only 25 observations, which does not leave any degree of freedom for a satisfactory estimation. Nevertheless, the results of its estimation will be presented for the sake of comparison with other models.

A "non-metric" conjoint analysis model applies a monotonic transformation on the dependent variable. Then, the model is iteratively adjusted until the transformation stabilizes (see annex). Equation (2) defines a non-metric conjoint analysis model:

$$\begin{aligned}\Phi y_{ijklmn} = \mu + \beta_{1i}x_{1i} + \beta_{2j}x_{2j} + \beta_{3k}x_{3k} + \beta_{4l}x_{4l} \\ + \beta_{5m}x_{5m} + \beta_{6n}x_{6n} + \epsilon_{ijklmn},\end{aligned} \quad (2)$$

where Φy_{ijklmn} designates a monotonic transformation of the variable y. If needed, monotonic transformations can also be applied on the attributes. This model would be worth considering in the present context of rank-ordered preference data, but it requires the estimation of additional parameters for transforming the dependent variable. Hence, it would lead to a deficit in degrees of freedom.

Metric conjoint analysis can be taken as a special case of non-metric conjoint analysis. In both models, numerical part-worth utility values are computed for each level of each attribute. Then, the weights given to each attribute by a manager in his/her decision making can be derived. However, we should be aware that conjoint analysis is more a statistical descriptive tool than a model of decision making.

A variety of non-linear transformations can also be applied on the independent variables. Beyond monotonic transformations, additional specifications can be imposed. Polynomial functions and particularly piecewise polynomials or splines may provide more flexibility in estimation and lead to a better fitting model.

A special case of interest is a continuous linear spline model, because it can be compared with a multicriteria approach that will be considered below, and that is also based on a linear spline function. As an example, in a model with one independent variable x and with three knots a, b, and c, where linear segments connect,

$$y = \delta_0 + \delta_1 w_{1x} + \delta_2 w_{2x} + \delta_3 w_{3x} + \delta_4 w_{4x} + \epsilon, \tag{3}$$

and the independent variable x is transformed as follows:

$$\begin{aligned}
w_{1x} &= x \\
w_{2x} &= \begin{cases} 0 & \text{if } x \leq a \\ x - a & \text{if } a < x \end{cases} \\
w_{3x} &= \begin{cases} 0 & \text{if } x \leq b \\ x - b & \text{if } b < x \end{cases} \\
w_{4x} &= \begin{cases} 0 & \text{if } x \leq c \\ x - c & \text{if } c < x \end{cases}
\end{aligned}$$

Equation 3 can be estimated by a simple least square regression. As presented here, it involves 5 parameters: the constant intercept plus the coefficients of the four $w'_{ix}s$. If there are more attributes in the model, there will be four additional parameters for each additional attribute. In our case, that leads again to a model with 25 parameters. Moreover, it turns out that given the symmetric design of our stated preference experiment, to which the knots are fitted, there is actually no difference between the simple conjoint analysis and the one with a linear spline specification. A non-metric CA model with spline transformations could be set up as well, but it would also confront a severe deficit of degrees of freedom.

Thus, it appears that a conjoint analysis approach is not adapted to analyse our survey's data. Nevertheless, we could reduce its complexity by taking the independent variables as continuous while applying a monotone transformation on the ranking dependent variable. The results of such a simplified model are presented in section 5.

3 The UTA multi-criteria analysis

Like many multi-criteria approaches, the UTA model, proposed initially by Jacquet-Lagrèze and Siskos (1978, 1982), aims at estimating a utility function or utility values, and allows to compute the attributes' weights for individual decision makers. An advantage of this particular method is that it estimates non-linear utility functions, whereas the usual discrete choice models provide only a linear utility function with constant coefficients. It is a model specifically designed to derive utility functions on the basis of a preference ranking. Hence, it is particularly appropriate to our purpose and our data since we wish to value a set of transport alternatives on the basis of preference rankings given by transport managers. Moreover, it constitutes a real model of decision making.

The measurements of criteria are given by the vector

$$g(a) = (g_1(a), g_2(a), ..., g_N(a))$$

for any alternative a belonging to A. In our case, the $g_i(a)$'s measure the attributes of the transport solutions under consideration: their Cost, Reliability, Frequency, Flexibility, Time, and Safety. The model assumes the existence of a additive utility function which satisfies the classic axioms of decision theory, namely the axioms of comparability, reflexivity, transitivity of choices, continuity and strict dominance.

The utility function is additive,

$$U(g(a)) = \sum_{i=1}^{N} u_i(g_i(a)) \tag{4}$$

$$\text{with } u_i(g_i) \geq 0 \text{ and } \frac{du_i}{dg_i} \tag{5}$$

The additive function implies in particular that the partial utility of a criterion $u_i(g_i(a))$ depends only on the level of that particular criterion[1]. Condition (5) guarantees that the functions are monotone increasing with respect to increasing levels of a favourable attribute. Hence, each attribute must be defined as a favourable factor. In our case, this means that the cost and Time attributes must be sign-inverted to fit in the model. Condition (5) can be seen as a minimal requirement of judgement rationality.

The utility function provides an aggregation of the criteria in a common index to compare and value the alternatives under consideration, and ranks the projects in a complete weak order. The UTA method, estimates the function U on a set of reference alternatives A by the method of linear goal programming proposed by Charnes and Cooper (1961, 1977). It provides an

[1] For a discussion about additive utility functions see Keeney and Raiffa (1976) and Fishburn (1967)

approximation by linear intervals of a non-linear function, similar to a linear spline specification in conjoint analysis.

In order to apply that method, the field of variation of each criterion $[g_{i*}, g_i^*]$, defined by its least favourable value of that criterion (g_{i*}) and its best value (g_i^*), is divided in α_i equal intervals $[g_i^j, g_i^{j+1}]$. The variables to be estimated by the program are the partial utilities at these bounds, say $u_i(g_i^j)$. The utility at intermediate values of the criteria are given by linear interpolation. Thus, for $g_i(a) \in [g_i^j, g_i^{j+1}]$,

$$u_i\left[g_i(a)\right] = u_i(g_i^j + \frac{g_i(a) - g_i^j}{g_i^{j+1} - g_i^j}[u_i(g_i^{j+1}) - u_i(g_i^j)]. \tag{6}$$

For each pair of transport alternatives (a, b) belonging to A, the decision-maker must express his/her preferences or indifferences. Under the version proposed by Despotis et al. (1990), the so-called UTASTAR version, the results of these comparisons are introduced as constraints consistent with conditions (5) and (6), i.e.

$$\sum_{i=1}^{N} \{u_i(g_i(a)) - u_i(g_i(b))\} + \sigma^+(a) - \sigma^-(a) - \sigma^+(b) + \sigma^-(b) \geq \delta \Longleftrightarrow \text{a } P \text{ b} \tag{7}$$

$$\sum_{i=1}^{N} \{u_i(g_i(a)) - u_i(g_i(b))\} + \sigma^+(a) - \sigma^-(a) - \sigma^+(b) + \sigma^-(b) = 0 \Longleftrightarrow \text{a } I \text{ b} \tag{8}$$

with all σ^+ and $\sigma^- \geq 0$. σ^+ corresponds to a positive error with respect to the difference between utility levels, whereas σ^- indicates a negative error. These errors are all non-negative, they represent the possible errors of an action's utility estimation. The parameter δ on the right side of the inequality 7 must be strictly positive. The objective function F to be minimised is the sum of these errors:

$$F = \sum_{a \in A'} [\sigma^+(a) + \sigma^-(a)] \tag{9}$$

The hypothesis that the partial utilities increase with the value of the criteria imposes a series of additional constraints:

$$u_i(g_i^{j+1}) - u_i(g_i^j) \geq s_i \qquad j = 1, 2, \ldots, \alpha_i, i = 1, 2, \cdots, N \tag{10}$$

where s_i must be (strictly) positive. Like for δ, it is better initially to give it a small value. Finally the partial utilities are normalised by the conditions

$$\sum_{i=1}^{N} u_i(g_i^*) = 1, \tag{11}$$

$$\text{and } u_i(g_{i*}) = 0 \qquad \forall i \tag{12}$$

Equation (10) indicates that the values of $u_i(g_i^*)$'s, the criteria's utilities at their highest levels, correspond to the criteria's relative (average) weights in the utility function.

All these constraints together with the minimization of the sum of errors constitute the basic linear goal programming model UTA-UTASTAR that is applied here. The interested reader may find additional details and a few other specifications, as well as a set of comparative simulations, in Beuthe and Scannella (1996, 2001). Some of these specifications include further constraints for handling additional information that may be given by the decision maker.

Since, it is a linear programming model, the problem of degrees of freedom does not arise from a technical point of view. However, as it is often the case in linear programming, the solution may not be unique. This problem must then be solved by a post-optimality analysis. Jacquet-Lagrèze and Siskos (1978) have simply proposed to use a function which is the average of the extreme optimal functions obtained from a sensitivity analysis applied on the last bounds of each criterion. This sensitivity analysis is made with an additional constraint

$$\sum_{a \in A'} \sigma(a) \leq F^* + \theta, \tag{13}$$

where θ is small positive number. This procedure was shown to provide a practical and efficient method of estimation. Other solutions may be found in Beuthe and Scannella (1996, 2001).

Another version of this model, named Quasi-UTA, imposes that the utility function be either concave or convex (or linear). This is implemented by imposing a recursive exponential form on the utility function (Scannella (2001)). This form involves only one curvature parameter plus one relative weight factor for each partial utility function. Hence, in the present case, it involves only 11 parameters, whereas the UTA estimation requires 23 parameters. This specification transforms the model into a non-linear program.

The main advantge of the above multi-criteria models is that they do not use the rankings as if they were ratings with a constant scale. Beside that, there are two other important differences. First, conjoint analyses minimise the sum of squared errors, whereas UTA models minimise the sum of errors in absolute values. Hence, conjoint analysis results are more influenced by extreme observations or outliers. Second, the multi-criteria models impose that the partial utility functions be monotonically increasing, whereas no such constraint is imposed in conjoint analyses.

4 The rank-ordered logit model (ROL)

Another approach to analyse data of individual rank-ordered preferences follows the line of discrete choice modelling, in particular logit-type models. These purport to estimate the probability of choosing an alternative on the basis of the decider's utility, which is assumed to be random with a double exponentially distributed error term. The expected utility, the estimation object, is a function of the alternatives' attributes and/or the decider's characteristics. In the context of our problem, analysing individual data, only the alternatives' attributes are considered. Hence, the model(s) can be placed in the family of conditional logit models first analysed by McFadden (1974).

Rank-ordered data require a particular specification of the stochastic utility model, which has been developed by Luce (1959) and Luce and Suppes (1965) from a theoretical point of view, and empirically implemented by Beggs et al. (1981) and Chapman and Staelin (1982).

The Luce and Suppes "Ranking Choice Theorem" leads to the following decomposition of a joint ranking probability:

$$\begin{aligned} P(1,2,...,J) &= P(1|\{1,2,...,J\}).P(2|\{2,3,\ldots,J\}) \\ &\quad \ldots P(J-1|\{J-1,J\}) \\ &= \prod_{j=1}^{J-1} P(j|\{j,j+1,\ldots,J\}). \end{aligned} \tag{14}$$

In equation (14), $P(1,2,,J)$ is the probability of a joint ranking such that alternative 1 is preferred to alternative 2, and the latter to alternative 3, etc., whereas $P(j|\{j,j+1,\ldots,J\})$ is the probability that alternative j is chosen in the set containing alternatives from j to J. Thus equation (14) states that the probability of a joint ranking of J alternatives is equal to the product of probabilities of $J-1$ independent choices made with respect to successively reduced choice sets. This result is obtained from the assumption of independence of irrelevant alternatives; here, it determines successive probabilities that are not affected by the ranking of alternatives that are not chosen.

In the framework of the stochastic utility model, the same result is obtained by assuming that the random error terms ϵ_j in the linear additive utility function are independent and identically distributed according to a type I extreme-value distribution (Gumbel distribution). Thus, assuming that the utility function is:

$$U_j = V_j + \epsilon_j = X_j'\beta + \epsilon_j = \sum_i \beta_i x_{ij} + \epsilon_j \tag{15}$$

with the cumulative distribution,

$$F(\epsilon_j < \epsilon) = exp(-e^{-\epsilon}) \tag{16}$$

where, j refers to a particular alternative and i to one of the attributes. Then, it follows that the probability of a ranking is simply a product of logit choice probabilities with respect to successively reduced choice sets Beggs et al. (1981):

$$\begin{aligned} & Pr(u_1 > u_2 > \ldots > u_J) \\ &= \prod_{j=1}^{J} P(u_j > u_m, \forall m > j) \\ &= \prod_{j=1}^{J-1} \frac{\exp(V_j)}{\sum_{m=j}^{J} \exp(V_m)} \end{aligned} \tag{17}$$

The corresponding log-likelihood function is:

$$L(\beta) = \sum_{j=1}^{J-1} (V_j) - \sum_{j=1}^{J} \ln \left(\sum_{m=j}^{J} \exp(V_m) \right) \tag{18}$$

This decomposition of the probability of a ranking into a product of probabilities of independent choices is referred to as an "explosion process", which allows an efficient exploitation of data to the extent that it creates statistically independent choice observations (Chapman and Staelin (1982)). After generating the exploded data, the estimation can proceed along the lines of a conditional logit computation.

This model must be distinguished from the so-called "ordered response models" which would estimate the probability that an alternative falls into one among an ordered set of categories: category 1 if the alternative's utility is greater than $X'\beta + \alpha_1$, category 2 if the utility is between $X'\beta + \alpha_1$ and $X'\beta + \alpha_2$, with $\alpha_1 > \alpha_2$, category 3 if the utility is between $X'\beta + \alpha_2$ and $X'\beta + \alpha_3$, with $\alpha_2 > \alpha_3$, etc. (Maddala (1983)). The structure of this model does not entirely correspond to our problem. Furthermore, with 25 transport alternatives, this approach requires the estimation of a large number of additional parameters α_i for defining 25 categories. Hence, no attempt was made to estimate such a model.

The rank-ordered model assumes that the error terms are independent and identically distributed. However, it could be the case that an interviewee gives less attention to the ranking of the less attractive alternatives. One might fear then that these observations' errors would be affected by larger variances. On the other hand, our ranking data result from a two-steps process: in order to facilitate the interviewees' task, it was suggested that they first partition the set of alternatives into three groups according to the more or less interest they had for them, then to rank the alternatives inside each group. These two separate reasons lead us to consider a two-stages "nested logit model" (McFadden (1982)), which could, to some extent, tackle both aspects, while maintaining the rank-ordered specification.

Indeed, the nested logit model can structure the choice problem exactly in the way it was submitted to the interviewees: first distribute the alternatives into three different preference groups, then rank each group's alternatives. Hence, in a stochastic utility model, the probability of choosing an alternative j that is an element of group l can be defined as the conditional probability of choosing this alternative within group l multiplied by the probability of choosing that group, i.e. $P_{lj} = P_{j|l}.P_l$.

Moreover, it allows for correlation of utilities within each group, whereas utilities in different groups remain independent; also the variances can be different between groups. One could have wished to set up a more detailed heteroskedastic model, even inside each group, but that would have been equivalent to introducing the dependent variable (ranking) into the set of independent variables.

Here, the utility function is assumed to be

$$U_{lj} = V_{lj} + \epsilon_{lj} = X'_{lj}\beta + \epsilon_{lj}, \tag{19}$$

with X_{lj}, the vector of attributes of alternative j within group l, and ϵ_{lj} as the corresponding random error. In our case of three groups, the error terms are distributed according to the generalized extreme-value distribution (GEV):

$$F(\epsilon_{11}, \epsilon_{12}, \ldots, \epsilon_{lm}, \ldots, \epsilon_{3J}) =$$
$$exp\left\{\left[\sum_{m=1}^{M_1} -e^{V_{1m}/\tau_1}\right]^{\tau_1} + \left[\sum_{m_2}^{M_2} -e^{V_{2m}/\tau_2}\right]^{\tau_2} + \left[\sum_{m_3}^{M_3} -e^{V_{3m}/\tau_3}\right]^{\tau_3}\right\} \tag{20}$$

with alternatives m_1 to M_1 in group $l = 1$,

$m_2 = M_1 + 1$ to M_2 in group l=2,

$m_3 = M_2 + 1$ to $M_3 = J$ in group l=3.

The probabilities are:

$$\begin{aligned} P_{jl} &= P_{j|l}.P_l \\ P_{j|l} &= \frac{exp(V_{lj}/\tau_l)}{\sum_{j=m_l}^{M_l} exp(V_{lj}/\tau_l)} \\ P_l &= \frac{exp(\tau_l I_l)}{\sum_{l=1}^{3} exp(\tau_l I_l)} \\ \text{where} \quad I_l &= ln \sum_{j=m_l}^{M_l} exp(V_{lj}/\tau_l). \end{aligned} \tag{21}$$

Then, introducing the nested structure in the rank-orderd logit, the rank-ordering probability for one individual becomes:

$$Pr\{u_{11} > u_{12} > \ldots > u_{3J}\} = \prod_{l=1}^{3} \prod_{j=m_l}^{M_l} \frac{exp(V_{lj})}{\sum_{m=j}^{M_l} exp(V_l)} \cdot \frac{exp(\tau_l I_l)}{\sum_{l=1}^{3} exp(\tau_l I_l)}, \quad (22)$$

Hence, the log-likelihood function to be maximised is:

$$L(\beta, l) = \sum_{l=1}^{3} \sum_{m_l}^{M_l} \left(ln(P_{m|l}) + ln(P_l) \right) \quad (23)$$

The parameters τ_l have values between 0 and 1 if nested logit is the correct specification. If they all equal 1, the nested structure recover the original conditional logit. McFadden (1978) proved that a sufficient condition for a nested logit model to be consistent with stochastic utility maximisation is that the coefficient τ_l lie in unit interval. So, if the τ_l value is outside the unit interval, this can be viewed as evidence of a specification error.

5 Comparative analysis of results

As indicated earlier, the analysed data are rankings of 25 transport alternatives done by nine transport managers during individual face-to-face interviews. An alternative is defined on 6 attributes varying on 5 levels, a level "0" corresponding to the current transport solution for his/her company, and the other 4 levels being variations with respect to the current situation: +10%, +20%, -10%, -20%. The attributes are Frequency of service per week, door-to-door transport Time, Reliability as % of deliveries at the scheduled time, carrier's Flexibility in response to non-programmed shipments (%), Loss as percentage of commercial value lost from damages, stealing and accidents, and transport Cost. The design matrix of these alternatives follows a fractional factorial scheme corresponding to an orthogonal set of alternatives (Addelman (1962)). Each respondent was asked to sort out the 25 alternatives in three groups, from the most to the least preferred, then to rank-order alternatives inside each group.

In this section, the estimation results obtained from five different methods are presented: the simple metric conjoint analysis, the UTA and Quasi-UTA multi-criteria analyses, the simple rank-ordered logit analysis, and the nested rank-ordered logit.

At this point, it is worth reminding that conjoint analysis minimises the sum of squared errors, whereas the UTA approaches minimise the sum of errors (in absolute values). Also, multi-criteria models impose that the partial utility functions be monotone increasing, whereas there is no such constraint in conjoint analysis.

The five models also differ in the number of parameters they estimate. As explained above, the simple conjoint model estimates 25 parameters; the UTA specification involves 23 parameters, whereas the Quasi-UTA specification reduces that number to 11. On the other hand, the rank-ordered logit model relies on only six coefficients for the six attributes, whereas the nested model requires three more parameters for the three groups' distribution coefficients plus one parameter corresponding to the constraint $\tau_i \geq 0$.

To conduct this detailed analysis, nine firms have been selected for the contrasting values taken by their typical shipments. These values are given in Table 1.

Table 1: *Characteristics of companies*

	Sector	Mode	Distance (km)	Travel time	Cost (€/Ton-km)	Shipment Size (Ton)
A	Steel	multim.	991	240h	0,038	350
B	Steel	waterw.	404	55 h.	0,017	900
C	Textile	multim.	2104	120h	0,11	15
D	Electron.	road	800	48h	0,12	23
E	Chemical	rail	1200	48h	0,002	23
F	Cement	road	123	3h	0,25	31,5
G	Packing	road	500	10h	0,16	12
H	Pharma	road	240	24h	0,96	0,1
I	Materials	waterw.	155	48h	0,025	1000

The basic criteria to judge the fitting quality of the models is the Kendall's tau τ_K, which is a correlation measure between the observed and the estimated rankings (see annex). The latter are derived from the alternatives' utilities as computed by each model. For some models, t-values also help to assess the quality of estimation.

For all models, the relative importance of attributes, or their weights, have been computed as averages over their domain of variation (see annex). Hence, they do not entirely translate the information on marginal effects that is provided by non-linear models, like conjoint or multi-criteria analyses.

The following tables 2 to 4 allow the comparison of the simple metric conjoint analysis, and the non-metric linear regression results.

Table 2: *Weights of a simple conjoint analysis*

	τ_K and R^2	Frequ.	Time	Reliab.	Flexib.	Loss	Cost
A	1,000	8,00%	9,14%	20,57%	6,29%	8,57%	47,43%
B	1,000	6,43%	14,34%	7,91%	4,83%	26,68%	39,81%
C	1,000	8,59%	23,39%	5,54%	10,96%	22,03%	29,49%
D	1,000	16,82%	28,20%	16,59%	7,35%	7,11%	23,93%
E	1,000	12,72%	2,04%	18,32%	13,10%	12,72%	41,09%
F	1,000	4,90%	7,35%	27,57%	5,51%	9,80%	44,87%
G	1,000	11,30%	6,63%	22,29%	5,42%	3,01%	51,36%
H	1,000	13,39%	6,70%	31,70%	8,93%	17,86%	21,43%
I	1,000	0,00%	0,00%	16,67%	0,00%	0,00%	83,33%
	Mean	9,13%	10,86%	18,57%	6,93%	11,98%	42,53%

Table 3: *Weights of a non-metric conjoint analysis with linear utility function*

	τ_K	R^2	Frequ	Time	Reliab	Flexib	Loss	Cost
A	0,773	0,961	1,19%	1,11%	20,02%	9,76%	10,92%	56,99%
B	0,713	0,938	5,65%	1,24%	12,47%	6,35%	23,36%	50,93%
C	0,640	0,915	11,37%	26,11%	1,16%	5,81%	9,62%	45,94%
D	0,653	0,909	12,10%	35,97%	18,44%	0,73%	1,46%	31,30%
E	0,740	0,869	8,87%	1,76%	21,93%	4,11%	11,62%	51,72%
F	0,760	0,934	1,44%	1,53%	31,11%	9,65%	7,66%	48,61%
G	0,793	0,942	0,43%	4,86%	25,35%	7,82%	3,01%	58,54%
H	0,500	0,756	17,31%	5,07%	30,32%	3,31%	6,04%	37,94%
I	1,000	1,000	0,00%	0,00%	16,67%	0,00%	0,00%	83,33%
		Mean	6,48%	8,63%	19,72%	5,28%	8,19%	51,70%

Table 4: *Estimates from an non-metric conjoint analysis with linear utility function*

cpy		Intercept	Frequ	Time	Reliab	Flex	Loss	Cost
A	Estimate	13,00	-0,96	-0,90	16,10	7,85	-8,78	-45,83
	t Value	*38,93*	*-0,41*	*-0,38*	*6,82*	*3,32*	*-3,72*	*-19,41*
B	Estimate	13,00	-4,81	-1,05	-10,61	-5,40	-19,87	-43,32
	t Value	*30,62*	*-1,60*	*-0,35*	*-3,53*	*-1,80*	*-6,62*	*-14,43*
C	Estimate	13,00	10,04	-23,06	-1,02	5,13	-8,50	-40,57
	t Value	*26,18*	*2,86*	*-6,57*	*-0,29*	*1,46*	*-2,42*	*-11,55*
D	Estimate	13,00	11,19	-33,27	17,06	0,67	1,35	-28,95
	t Value	*25,35*	*3,09*	*-9,18*	*4,70*	*0,19*	*0,37*	*-7,99*
E	Estimate	13,00	7,24	1,43	17,91	3,35	9,49	-42,24
	t Value	*21,16*	*1,67*	*0,33*	*4,12*	*0,77*	*2,18*	*-9,72*
F	Estimate	13,00	-1,20	-1,27	25,95	8,05	6,39	-40,55
	t Value	*29,66*	*-0,39*	*-0,41*	*8,37*	*2,60*	*2,06*	*-13,08*
G	Estimate	13,00	0,33	-3,73	19,44	5,99	-2,31	-44,90
	t Value	*31,75*	*0,11*	*-1,29*	*6,72*	*2,07*	*-0,80*	*-15,51*
H	Estimate	13,00	14,69	4,31	25,72	-2,81	-5,13	-32,19
	t Value	*15,50*	*2,48*	*0,73*	*4,34*	*-0,47*	*-0,86*	*-5,43*
I	Estimate	13,00	0,00	0,00	10,00	0,00	0,00	-50,00
	t Value							

Given that conjoint analysis does not leave any degree of freedom, it is not surprising to obtain a R^2 as well as a τ_K equal to 1[2]. In contrast, the linear regression obtains a lower coefficient τ_K. The pattern of weights is similar: Cost appears as the main decision factor, followed by Reliability. Time also is important in the two cases of the textile (C) and electronic (D) firms. The other factors do not seem to affect very much the decision.

Table 4 gives the econometric results of the linear regression. The levels of significance of attributes follow the pattern of the weights. Cost is always highly significant. We observe that signs are not always correct, except in the case of the Cost attribute. Note that, given the lack of degrees of freedom, no t-value can be computed to assess the meaningfulness of the partial utilities in the present conjoint analysis. In the latter, we also observed that signs were often not correct.

Table 5 and 6 allow to compare the UTA and Quasi-UTA results to those obtained above. The UTA model obtains a very high τ_K partly for the same reason as for the conjoint analysis model, since it consumes the equivalent of 23 degrees of freedom. Nevertheless, Quasi-UTA model reaches a level of τ_K that is not much lower, even though it has only 11 parameters and imposes a constraining specification on the utility function. There is no measure equivalent to a t-value in the UTA and Quasi-UTA programming models.

In both analyses, the pattern of weights is similar to the one observed above with Cost coming first followed by reliability, even though the latter weights are somewhat smaller.

Table 5: *Weights of UTA*

	τ_K	Frequ.	Time	Reliab.	Flexib.	Loss	Cost
A	0,978	0,80%	2,90%	11,50%	4,20%	8,40%	72,20%
B	0,947	0,30%	0,80%	0,10%	0,40%	32,70%	65,80%
C	0,933	8,10%	26,70%	14,50%	6,00%	14,60%	30,10%
D	0,962	17,40%	36,00%	13,90%	6,90%	4,30%	21,50%
E	0,909	0,30%	0,00%	0,10%	0,40%	0,10%	98,30%
F	0,945	0,10%	0,10%	1,10%	0,20%	0,00%	98,50%
G	0,978	0,30%	0,00%	9,20%	0,20%	0,10%	90,20%
H	0,930	7,60%	4,50%	35,80%	12,70%	18,70%	20,70%
I	1,000	0,00%	0,00%	16,70%	0,00%	0,00%	83,30%
	Mean	3,88%	7,89%	11,43%	3,44%	8,77%	64,51%

The UTA and Quasi-UTA models impose that the partial utilities be monotone increasing for favourable attributes, like Reliability or Flexibility, and they should be monotone decreasing for penalizing attributes, like Time or Cost. In conjoint analysis, this is obtained for the Cost and Reliability

[2]Hence, a non-metric transformation of the rankings would be useless

Table 6: *Weights of Quasi-UTA*

	τ_K	Frequ.	Time	Reliab.	Flexib.	Loss	Cost
A	0,931	0,20%	0,30%	3,00%	1,30%	1,60%	93,60%
B	0,922	1,80%	4,20%	0,10%	1,70%	35,90%	56,20%
C	0,930	3,50%	31,10%	6,30%	0,90%	20,70%	37,60%
D	0,866	20,30%	34,50%	17,80%	0,30%	0,10%	27,00%
E	0,848	0,20%	0,20%	0,90%	0,20%	0,10%	98,40%
F	0,893	2,10%	14,70%	35,20%	5,50%	1,30%	41,30%
G	0,966	0,20%	0,10%	3,20%	0,30%	0,10%	96,10%
H	0,895	14,00%	1,90%	35,20%	10,30%	20,20%	18,30%
I	1,000	1,00%	0,70%	11,70%	0,80%	0,70%	85,10%
	Mean	4,81%	9,74%	12,60%	2,37%	8,97%	61,51%

attributes, but not for the other attributes. For some firms, partial utilities are even in reversed order. These results illustrate the mechanical nature of conjoint analysis, susceptible to be led astray by some erroneous judgments made by the interviewed managers. This feature, plus the lack of degrees of freedom, which compounds the problem, lead us to conclude that conjoint analysis is not appropriate to extract meaningful decision rules from our individual interviews data.

The results of the logit models are given in tables 7 to 10. A likelihood ratio test between the two models suggested a better adequation of the nested model to the data, except in two cases (G and I). However, it appears, in table 7, that the inclusive value parameters τ_l are not significant in nested analyses, and that they have values greater than one. Hence, the hypothesis that there is a particular structure in the spread of errors between preference groups does not seem worth pursuing[3]. Furthermore, note that the levels of significance are always lower in the nested logit model.

In both logit models, we observe that the attributes that receive a heavy weight are also significant: as before, they are Cost followed by Reliability. In a few cases, Time, Loss and Frequency are significant and with a heavy weight. All the significant factors have the expected correct signs, like a positive sign for Reliability. The non-significant attributes receive small weights and may have contradictory signs, like in conjoint analysis. Frequency and Flexibility do not appear to play an significant role in decision making. Among all the models, the rank-ordered logit obtained the weakest τ_K values.

[3]In earlier work, a simple conditional logit estimation with two additional dummies for group memberships lead to the same observation. We may add here that an estimation of the error terms estimated in UTA and Quasi-UTA did not reveal any particular pattern

Table 7: *Estimates from rank-ordered nested logit analysis*

cpy		Frequ	Time	Reliab	Flex	Loss	Cost	τ_1	τ_2	τ_3
A	Estimate	-0,835	0,622	6,508	0,437	0,453	-22,774	27,946	3,698	0,000
	t Value	*-0,436*	*0,296*	*2,418*	*0,235*	*0,217*	*-4,000*	*0,013*	*0,016*	
B	Estimate	-1,267	-0,665	-0,145	1,754	-7,460	-12,294	77,770	22,446	0,000
	t Value	*-0,713*	*-0,340*	*-0,072*	*1,036*	*-3,441*	*-2,968*	*0,597*	*0,568*	
C	Estimate	1,083	-15,998	0,180	1,292	-10,654	-15,922	5,378	0,422	0,000
	t Value	*0,546*	*-2,688*	*0,088*	*0,407*	*-2,558*	*-2,807*	*0,019*	*1,176*	
D	Estimate	5,321	-11,984	3,139	-0,122	-0,900	-6,303	68,699	8,663	0,000
	t Value	*2,245*	*-3,426*	*1,773*	*-0,076*	*-0,516*	*-2,240*	*0,975*	*0,906*	
E	Estimate	0,688	-0,179	5,266	1,618	-0,080	-8,784	90,209	29,243	0,000
	t Value	*0,624*	*-0,111*	*2,559*	*0,930*	*-0,055*	*-2,754*	*0,624*	*0,568*	
F	Estimate	1,970	-2,357	16,984	6,560	4,235	-8,639	10,612	0,041	0,000
	t Value	*0,822*	*-1,055*	*3,123*	*2,718*	*1,602*	*-1,684*	*0,023*	*0,109*	
G	Estimate	-0,612	-0,748	9,072	1,537	-0,134	-15,016	8,372	0,736	0,000
	t Value	*-0,312*	*-0,372*	*3,093*	*0,800*	*-0,064*	*-3,004*	*0,021*	*1,645*	
H	Estimate	3,265	2,038	3,057	-1,108	-1,383	-0,268	120,014	10,894	0,000
	t Value	*1,799*	*1,218*	*1,427*	*-0,700*	*-0,956*	*-0,135*	*0,627*	*0,600*	
I	Estimate	-1,734	-1,607	143,275	-1,033	-1,467	-694,729	0,441	0,000	0,437
	t Value	*-0,001*	*-0,001*	*0,081*	*-0,001*	*-0,001*		*0,002*		*0,006*

Note: the τ_i's are constrained as > 0, what explains the zero-values of τ_3

Table 8: *Estimates from Rank-ordered logit analysis*

cpy		Frequ	Time	Reliab	Flex	Loss	Cost
A	Estimate	-0,061	0,454	8,968	1,272	-2,647	-21,667
	t Value	*-0,036*	*0,251*	*3,429*	*0,726*	*-1,368*	*-4,582*
B	Estimate	0,108	-4,218	-1,640	0,301	-6,713	-14,384
	t Value	*0,053*	*-2,052*	*-0,891*	*0,174*	*-3,212*	*-4,140*
C	Estimate	1,765	-13,941	1,157	3,002	-8,366	-15,846
	t Value	*1,108*	*-4,057*	*0,660*	*1,435*	*-3,646*	*-4,158*
D	Estimate	6,430	-11,921	5,790	1,312	0,919	-12,390
	t Value	*2,853*	*-3,999*	*2,877*	*0,721*	*0,484*	*-3,837*
E	Estimate	2,226	-0,323	6,912	2,487	2,416	-15,059
	t Value	*1,282*	*-0,177*	*3,139*	*1,411*	*1,359*	*-4,349*
F	Estimate	0,313	-1,183	10,020	2,382	3,053	-17,207
	t Value	*0,201*	*-0,675*	*3,651*	*1,308*	*1,668*	*-4,447*
G	Estimate	-0,625	-1,422	9,699	1,747	2,193	-20,903
	t Value	*-0,352*	*-0,735*	*3,759*	*0,928*	*1,093*	*-4,839*
H	Estimate	2,696	1,122	7,335	0,124	-3,633	-3,645
	t Value	*1,626*	*0,631*	*3,409*	*0,075*	*-2,008*	*-1,830*
I	Estimate	-0,022	-0,275	112,753	0,133	-0,081	-561,886
	t Value	*0,000*	*-0,001*	*0,179*	*0,000*	*0,000*	*-0,199*

Table 9: *Weights from rank-ordered nested logit analysis*

	τ_K	Frequ	Time	Reliab	Flex	Loss	Cost
A	0,787	2,64%	1,97%	20,58%	1,38%	1,43%	72,00%
B	0,727	5,37%	2,82%	0,62%	7,44%	31,63%	52,13%
C	0,720	2,40%	35,45%	0,40%	2,86%	23,61%	35,28%
D	0,613	19,16%	43,15%	11,31%	0,44%	3,24%	22,70%
E	0,713	4,14%	1,08%	31,69%	9,74%	0,48%	52,87%
F	0,593	4,84%	5,79%	41,68%	16,10%	10,39%	21,20%
G	0,787	2,26%	2,76%	33,45%	5,67%	0,49%	55,37%
H	0,433	29,36%	18,33%	27,49%	9,96%	12,44%	2,41%
I	1,000	0,21%	0,19%	16,98%	0,12%	0,17%	82,33%
	Mean	7,82%	12,39%	20,47%	5,97%	9,32%	44,03%

Table 10: *Weights from Rank-ordered logit analysis*

	τ_K	Frequ	Time	Reliab	Flex	Loss	Cost
A	0,793	0,17%	1,30%	25,57%	3,63%	7,55%	61,78%
B	0,760	0,40%	15,41%	5,99%	1,10%	24,53%	52,56%
C	0,720	4,00%	31,63%	2,62%	6,81%	18,98%	35,95%
D	0,700	16,59%	30,75%	14,94%	3,38%	2,37%	31,96%
E	0,773	7,57%	1,10%	23,49%	8,45%	8,21%	51,18%
F	0,773	0,92%	3,46%	29,34%	6,97%	8,94%	50,38%
G	0,820	1,71%	3,89%	26,51%	4,77%	5,99%	57,13%
H	0,647	14,53%	6,05%	39,53%	0,67%	19,58%	19,64%
I	1,000	0,00%	0,04%	16,70%	0,02%	0,01%	83,22%
	Mean	5,10%	10,40%	20,52%	3,98%	10,69%	49,31%

6 Conclusion

It is rather difficult to reach a clear-cut conclusion, since the comparison between the various estimates can only be based on the Kendall τ_K. No additional data are available for checking the reliable quality of estimation.

Nevertheless, several elements plead in favor of the multi-criteria estimates. First, as a matter of fact, their ranking correlations τ_K are higher. Second, these models are more robust in a statistical sense, since they do not assume any specific distribution. Third, they constraint the partial utilities of positive (negative) attributes, to be monotone increasing (decreasing), as they should be. Fourthly, their estimates are equivalent to averages, and, as such, can be taken as more reliable.

To the extent that the preliminary analysis of nine cases permit to draw any conclusion, it appears that "Cost" is, most often, the main factor of choice making. "Reliability" comes next. "Time" and "Loss" are much less important, but can play a role in some cases. "Frequency and "Flexibility" hardly play any role. These results clearly come out regardless of the methodology used.

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Appendix A
Conjoint Analysis estimation

The conjoint analyses discussed in this paper have been estimated with the SAS/STAT procedure PROC TRANSREG. Metric conjoint analysis models are fit using ordinary least squares, and non-metric models are fit using an alternating least squares algorithm (Young, 1981; Gifi, 1990). This computational process optimises a loss function by using an algorithm based on the alternating least squares (ALS) and optimal scaling (OS) principles. In our case with only discrete dependent and independent variables, the optimal scaling leads to a multiplication of each variable level by a specific scale parameter. If there is a monotone restriction imposed on the transformation, the set of parameters will respect the constraint of monotonicity. The alternating least squares procedure involves dividing all of the parameters into two mutually exclusive and exhaustive subsets: (a) the parameters of the model; and (b) the parameters of the data (called optimal scaling parameters)[4]. Then, a Multiple Optimal Regression by Alternating Least Squares (MORALS) is realized. This method iteratively optimises the multiple correlation coefficient with respect to one subset of parameters holding constant the other subset. That is to say, the least squares estimates of the parameters of one set are obtained assuming constant the parameters of the other subset. At each step, the previous estimates of parameters are replaced by the new estimates. The process is going on until convergence.

Note that this alternating procedure does not guarantee convergence on the globally least squares solution. It could give a local optimum. The optimum towards which the procedure converges depends only on the initialisation process, and two different initialisations may lead to two different local optima. Probably the best initialisation process, used in this program, is to start applying the estimation on the raw data without any scale transformation; after this initial step, the program starts applying the optimally scaled transformations.

[4]Young F.W. (1981). See also the discussion of the algorithms in SAS Technical Report R-108

Appendix B

Kendall tau

Kendall tau τ_K is produced from the CORR procedure (SAS). The Kendall tau is measure of correlation between the predicted and the actual ranking. Tau is computed for a data set of n (X,Y) pairs as the number of concordant pairs of data (Nc) minus the number of discordant pairs (Nd), divided by the number of total pairs, or Kendall's. Pairs which are tied are assigned a 0.

$$\tau_K = (Nc - Nd)/[n(n-1)/2] \tag{24}$$

Appendix C
Weights

For all analyses, the way to calculate the weight is the following. Given that the utility function is

$$U = \sum_{i=1}^{6} \beta_i x_i \tag{25}$$

Then, the weight for each criteria j, $j = 1, \ldots, 6$ is

$$w_j = \frac{|\beta_j|(x_j^* - x_{*j})}{\sum_{i=1}^{6} |\beta_i|(x_i^* - x_{*i})} \tag{26}$$

where x_i^* and x_{*i} are the maximum and the minimum value taken by the criteria.

La qualité des services de transport de marchandises: une analyse agrégée des ordres de préférence déclarés[1]

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La qualité des services de transport de marchandises: une analyse agrégée des ordres de préférence déclarés

Résumé

L'objectif de la recherche est d'estimer l'importance relative et la valeur pour les expéditeurs de marchandises de facteurs de décision qualitatifs tels que la fréquence de service, le temps de transport, la fiabilité des livraisons, la flexibilité d'ajustement du transporteur, et la sécurité du transport. La méthodologie est celle des préférences déclarées sur base d'un échantillon de chargeurs belges qui ont exprimé leur ordre de préférence parmi un certain nombre de solutions de transport hypothétiques définies par leur coût et leur niveau qualitatif. La technique économétrique utilisée est celle de l'analyse logit conditionnelle adaptée au traitement des ordres de préférence. Elle est appliquée non seulement à l'échantillon global, mais aussi à des sous échantillons d'observations regroupées selon la distance de transport, la valeur des marchandises, etc. Il ressort de cette analyse que les facteurs qualitatifs jouent un rôle important dans le choix d'une solution de transport, et que l'importance attribuée aux différents facteurs varie fortement selon les catégories de firmes et de transports considérés.

Freight transports quality of services: an aggregated analysis of stated orders of preference

Abstract

The research aims at the estimation of the relative importance and value for freight shippers of qualitative factors that characterize transport solutions: service frequency, transport time, reliability of delivery, carrier's flexibility, and safety. A stated preference methodology is applied with a sample of preference orders among hypothetical transport solutions stated by a set of Belgian freight shippers. These solutions are defined by their cost and the above qualitative factors. The econometric technique is the one of conditional logit adapted for handling preference orders. It is applied to the global sample, but also to sub-samples classified according to the transport distance, the goods' value, etc. This analysis shows that qualitative factors play an important role in the choice of a transport solution, and that their relative importance varies very much according to the categories of firms and transports.

La qualité des services de transport de marchandises: une analyse agrégée des ordres de préférence déclarés

1. Introduction

Devant l'expansion continue des transports de personnes et de marchandises qui provoque de nombreuses nuisances sur les routes, de la congestion, de la pollution, des accidents et du bruit, les autorités publiques souhaiteraient une redistribution des flux de transport de marchandises vers le chemin de fer, la voie navigable terrestre ainsi que le cabotage maritime. Pour bien comprendre ce qu'il est possible de faire en ce sens et l'organiser, il importe d'analyser les déterminants des choix de transport. En effet, ce choix ne se fait pas seulement par rapport au prix du transport, mais également par rapport à la qualité des services de transport, c'est-à-dire la fréquence des services proposés, le temps pris pour effectuer le transport, la fiabilité par rapport aux délais de livraison, la capacité du transporteur à satisfaire une demande inattendue, et la sécurité du transport. Cet article contribue à cette problématique par l'analyse des résultats obtenus à la suite d'une enquête réalisée auprès d'expéditeurs belges.

L'objectif de l'article est d'évaluer l'importance relative que les décideurs en la matière accordent aux attributs qualitatifs par rapport au coût du transport et de la mesurer en termes d'équivalent monétaire. Deux approches peuvent être utilisées pour ce faire. La première est l'analyse de décisions réellement prises par des managers, communément appelées analyse des préférences déclarées car ces décisions révèlent les poids qu'ils donnent aux divers attributs. La seconde recourt à l'analyse de jugements exprimés par rapport à des solutions de transport hypothétiques, que l'on appelle analyse des préférences déclarées. La première approche étant exigeante en termes de données sur les alternatives effectivement considérées, c'est la seconde qui est le plus souvent utilisée, bien qu'elle ne soit pas sans problème d'interprétation. Elle permet en tout cas de confronter un décideur à des alternatives bien définies parmi lesquelles il peut exprimer ses préférences. Elle crée ainsi de nombreuses données de choix qui peuvent faire l'objet d'une analyse économétrique détaillée.

Cette méthodologie a déjà fait l'objet d'un certain nombre d'applications dans divers pays avec des évaluations assez variées qui résultent largement des circonstances de transport analysées, c'est-à-dire de la nature des réseaux de transport, des marchandises transportées, des distances, des modes considérés, etc. Notre analyse et ses résultats sont aussi marqués par la spécificité de l'échantillon obtenu par l'enquête, qui sera détaillée dans la suite de l'article.

Mais les résultats sont aussi fonctions dans une certaine mesure des techniques d'enquête utilisées et des méthodes économétriques appliquées. De ce point de vue, notre travail se distingue de deux manières : en premier lieu, les choix des managers de transport ne devaient s'exprimer que par un rangement selon l'ordre de préférence entre alternatives, et non par une mesure d'utilité ; en second lieu, et par conséquent, le modèle économétrique correspond à ce type de classement, car il analyse exactement la suite des préférences exprimées pour chacune des alternatives par rapport aux alternatives qui lui sont jugées inférieures. Pour ce faire, nous avons adopté le modèle logistique conditionnel développé par Beggs et al. (1981) et Chapman et Staelin (1982). D'autres techniques d'analyses pourraient être également envisagées, par exemple le modèle économétrique de « rangement par ordre de réponse » [2] de Aitchison et Silvey (1957) et Asford (1959), mais aussi certaines techniques d'analyse multicritère, comme UTA ou Quasi-UTA, expérimentées par Beuthe et al. (2005). Elles ne sont pas appliquées dans cet article.

La section 2 de cet article donne la description du questionnaire d'interview développé pour cette recherche et le modèle expérimental utilisé pour obtenir des managers de transport leur rangement préférentiel entre différentes solutions hypothétiques de transport. La section 3 présente le modèle économétrique approprié (Beggs *et al.* 1981 et Chapman et Staelin, 1982) pour analyser des préférences exprimées selon un ordre de préférence. La section 4 suivante analyse les résultats obtenus par cette méthodologie. Une brève conclusion clôture l'article.

2. L'enquête et le modèle expérimental

La méthodologie des préférences déclarées est utilisée couramment dans le domaine du transport pour analyser les choix de solutions de transport, et en particulier les choix faits par les voyageurs. Une information abondante à ce sujet peut être trouvée, par exemple, dans le manuel récemment publié par l'U.K. Department of Tranport (2002). Au cours des dernières années, un certain nombre de recherches ont aussi été publiées dans le domaine du transport de marchandises. Certaines de ces publications méritent d'être signalées ici, par exemple Fowkes et Shingai, Bolis et Maggi, Fridstrom et Madslien, Maier et Bergman, toutes contributions éditées dans le livre de R. Danielis (2002), mais aussi Bergkvist (1998), Jovicic (1998), Matear and Gray (1993), STRATEC (1999), INRETS (2000), de Jong (2000 et 2004) et Danielis (2005). Cependant, beaucoup de ces recherches se limitent à l'analyse de transports très spécifiques, comme le choix entre les transports routiers et inter-modaux le

[2] « Ordered response model ». Voir aussi G.S. Maddala (1983).

long d'un corridor de transport, le choix entre le transport pour compte propre et le recours à un transporteur externe, ou se limitent simplement à l'analyse de la valeur du temps. De plus, les échantillons sont parfois assez restreints compte tenu du nombre de variables explicatives potentielles. Dans l'ensemble, ce problème mérite donc davantage de recherche, en particulier dans le contexte des transports belges pour lesquels aucune étude approfondie n'a jamais été réalisée. Ceci justifie notre intérêt pour cette problématique.

Les techniques d'interview, nécessaires pour obtenir l'information sur les préférences des décideurs, sont bien développées et largement utilisées dans beaucoup de domaines, et en particulier en marketing. Elles sont toujours délicates à utiliser, car les interviews doivent être ajustés à chaque problème particulier, à la nature de l'échantillon visé, … et au budget disponible. Le questionnaire proprement dit, et son modèle expérimental, pose également pas mal de difficultés. Enfin la modélisation du problème de décision et les techniques économétriques utilisées pour l'analyse des données constituent un autre domaine de recherche.

Les données de préférences déclarées utilisées pour cet article proviennent d'une enquête auprès de managers de transports de marchandises appartenant à des firmes expéditrices belges. Il a été réalisé par un consortium d'universités belges (Anvers, Gand, Louvain-La-Neuve et Mons). Sa méthodologie et son questionnaire sont basés sur une large revue de la littérature scientifique dans les domaines du transport, du marketing et de la statistique. Certaines des contributions que l'on peut y trouver ont déjà été mentionnées ci-dessus, mais il est opportun de citer aussi Green et Srivinisan (1990), Huber et al. (1996), Louvière et al. (2000), comme aussi Oppewal (1995 a and b), Carmone et Schaffer (1995), et Carroll et Green (1995) pour des revues de techniques et de programmes informatiques disponibles. Des références supplémentaires peuvent être trouvées dans l'article de Louvière and Street (2000), ainsi que dans le manuel de l'U.K. Department of Transport (2002).

Quelques interviews en profondeur de managers furent réalisées durant la rédaction du questionnaire. Sa faisabilité fut ainsi testée et permit un certain nombre d'ajustements. En fait, il fut finalement un compromis entre le désir de rassembler autant d'information que possible et des considérations pratiques tenant aux limites qu'imposent une enquête. Il fut choisi de faire des interviews face-à-face, car elles permettaient d'obtenir des informations supplémentaires au cours d'un dialogue, ainsi que de vérifier la bonne compréhension du questionnaire par le manager interviewé.

Le questionnaire et l'expérience de préférences déclarées furent administrés sur papier sans support informatique. Les études publiées à ce sujet ont considérés quatre à sept différents attributs de service, parmi lesquels notre groupe de recherche choisit et définit six attributs apparemment significatifs. C'est un nombre que la littérature dans le domaine considère possible dans la réalité d'une interview. De plus, nous avons considéré qu'il valait mieux présenter chaque alternative de transport en la définissant de façon complète par rapport aux six attributs. Afin de faciliter cette tâche, chaque alternative fut présentée sur une carte séparée. Cela permettait de comparer de façon commode les alternatives et de les classer, avec toujours la possibilité de corriger son jugement et de modifier le classement durant l'exercice de préférence. Nous avons choisi aussi de demander seulement un rangement par ordre de préférence, et non pas une évaluation de l'utilité de chaque alternative. En effet, nous avons jugé une telle tâche assez difficile pour la personne interviewée, alors que un simple classement de préférences procurait déjà une information substantielle. Enfin, il fut décidé de limiter le nombre d'alternatives en adoptant un modèle factoriel expérimental fractionnaire orthogonal selon la proposition de Addelman (1962). Dans l'ensemble, ce dispositif d'interview fut accepté comme réaliste et faisable par la plupart des managers qui y ont été soumis, soit plus de 130 personnes. Notons que ce modèle factoriel implique que seuls les effets directs des attributs sur les préférences peuvent être analysés, tandis que les effets d'interaction entre attributs sont négligés.

L'enquête vise le groupe des firmes de 20 employés au moins, qui expédient des marchandises de tout type et vers toute destination européenne. Les intermédiaires logistiques qui organisent des expéditions pour l'industrie sont inclus dans ce groupe. Les modes considérés sont le rail, la route, la navigation intérieure, le cabotage maritime, ainsi que leurs combinaisons inter- et multimodales. Etant donné la petite dimension du territoire belge, aucune origine de transport n'est exclue, même si elle peut avoir une accessibilité réduite par rapport à certains modes. L'attention étant centrée sur le transport interurbain et les possibilités de changement de solution de transport, les activités de distribution urbaine sont exclues de l'enquête. Cependant, aucune distance minimale de transport n'est fixée, même si l'intérêt d'autres transports que la route est réduit sur de courte distance. En effet, il existe en Belgique des cas de transport de marchandises industrielles sur de courtes distances par chemin de fer et par voie navigable.

Malheureusement, beaucoup de firmes sont réticentes à l'interview par manque d'intérêt pour la démarche scientifique, le manque de temps ou pour raison de confidentialité. Il s'ensuit que, comme pour d'autres études similaires, l'échantillon d'analyse est relativement restreint : 123 interviews nous ont donné des informations suffisamment complètes, alors que nous avons contacté par correspondance et conversation téléphonique 572 firmes. Il est donc difficile de qualifier cet échantillon de représentatif, bien que, pour autant que la comparaison soit possible, il corresponde approximativement à la répartition entre modes ainsi qu'à la distribution du chiffre d'affaires des firmes interviewées. Ce nombre assez réduit ne peut évidemment couvrir l'ensemble des situations de transport en Belgique. Toutefois, l'analyse détaillée par sous-groupes de la Section 4 procure beaucoup d'enseignements utiles qui indiquent une très grande variété d'attitude dans le chef des gestionnaires de transport[3]. La composition de l'échantillon est discutée davantage au cours de la Section 4.

Les interviews suivent un questionnaire composé de quatre parties. En premier lieu, une série de questions visent les caractéristiques générales de la firme, et, en particulier l'organisation du site à partie duquel l'expédition est faite. Ensuite, il est demandé de décrire un flux de transport typique à partir de ce site, notamment par les niveaux des six attributs objets de l'analyse. Ce flux sera utilisé comme référence dans l'expérience de préférences déclarées. Cet exercice peut alors prendre place, qui mène à un classement par ordre de préférence d'alternatives définies par rapport aux niveaux des attributs du flux typique de référence. Finalement, une série de questions tentent d'évaluer dans quelle mesure le manager interviewé serait prêt à changer de moyen ou de mode de transport pour utiliser une des alternatives qu'il a préféré dans la troisième étape.

La première série de questions concernent la taille de la firme, son type d'activité, son accessibilité par rapport au réseau de transport, la façon dont les décisions de transport sont prises, etc. Elles obtiennent ainsi des informations sur des dimensions qui peuvent être introduites comme variables explicatives des comportements dans une analyse économétrique. Certaines de celles-ci sont utilisées en section 4 pour définir des sous-groupes d'analyse.

La seconde partie du questionnaire conduit le décideur à choisir et décrire un flux typique de transport : la marchandise expédiée, son origine et sa destination, la distance, le tonnage annuel, la fréquence d'expédition et sa taille, le type de destinataire, la valeur et les caractéristiques du bien, etc. Ensuite, le décideur doit donner le niveau des six attributs retenus. Certains de ces attributs sont définis en pourcentages de réalisation afin d'y inclure l'idée du risque qui caractérise ces attributs. Ils sont définis de la façon suivante :

- la Fréquence de service par semaine, qui est effectivement proposée par le(s) transporteur(s) ou intermédiaire(s),

[3] Une analyse par firme individuelle, comme dans Beuthe et al. (2005), fait apparaître aussi apparaître une très grande variété d'attitudes.

- le Temps mis par le transport de l'origine à la destination, y compris le chargement et le déchargement,
- la Fiabilité en termes de pourcentages de livraison réalisée à temps,
- la Flexibilité en termes de pourcentage de demandes de transport inattendues qui ont pu être honorées par le(s) transporteur(s) sans délai excessif,
- la Sécurité, c'est-à-dire l'absence en pourcentage de pertes et de dégâts des marchandises durant le transport,
- le Coût est le prix payé pour le transport, y compris le chargement et le déchargement.

Dans la partie centrale du questionnaire, l'interviewé doit ranger les alternatives proposées par ordre de préférence. Celles-ci sont définies par leurs six attributs. Les niveaux des attributs sont donnés en pourcentages de variation par rapport au flux typique de référence. Toutefois, l'interviewé est invité à garder à l'esprit les valeurs des attributs du flux typique et d'interpréter les variations en pourcentages par rapport à cette situation réelle de référence. Certaines alternatives définies de cette façon sont présentées dans le tableau 1. Cette façon de procéder permet d'utiliser les mêmes cartes pour toutes les interviews alors même que la situation de référence varie d'une firme à l'autre. Elle définit aussi de façon claire la situation de référence pertinente à partie de laquelle un changement pourrait être envisagé (Department of Transport, 2002, ch. 12).

Comme il est montré dans le Tableau 1, cinq niveaux de variation seulement sont considérés : plus ou moins 10%, plus ou moins 20% et le niveau 0 de variation. La première alternative définie par des variations nulles évidemment correspond à la situation de référence. Quant à la deuxième alternative, elle est caractérisée par une variation positive de 10% du Temps et de la Fiabilité, une augmentation de la Flexibilité de 20% et des diminutions de la Sécurité et du Coût, respectivement de 10% et 20%. Ceci signifie, par exemple, que si le coût est de 100 € avec une fiabilité de 80% pour l'alternative 1 de référence, le coût de l'alternative 2 est seulement de 80 € et sa Fiabilité atteint les 88%.

Tout ceci est soigneusement expliqué au décideur au début de l'exercice de préférence déclarée. Dans certains cas, une valeur de référence peut être proche ou égale à 100% (ou 0%), en sorte que la variation est sujette à une contrainte. Cette dernière est alors indiquée au décideur afin qu'il en tienne compte dans ses évaluations.

Les interviews « face-à-face » donnent la possibilité de guider l'interviewé si nécessaire, de recueillir ses commentaires oraux complémentaires, et d'observer comment il procède pour classer les alternatives. Ces observations sont très utiles pour interpréter les préférences individuelles et vérifier les résultats obtenus.

Tableau 1 : Exemples d'alternatives proposées

	Fréquence	Temps	Fiabilité	Flexibilité	Sécurité	Coût
1	0%	0%	0%	0%	0%	0%
2	0%	10%	10%	20%	-10%	-20%
3	0%	20%	20%	-20%	10%	-10%
4	0%	-10%	-10%	10%	-20%	20%
5	0%	-20%	-20%	-10%	20%	10%
6	10%	0%	10%	10%	10%	10%
-	-	-	-	-	-	-
15	20%	-20%	10%	0%	-20%	-10%
16	-10%	0%	-10%	-10%	-10%	-10%
17	-10%	10%	-20%	0%	10%	20%
-	-	-	-	-	-	-
23	-20%	20%	10%	-10%	0%	20%
24	-20%	-10%	20%	0%	-10%	10%
25	-20%	-20%	-10%	20%	10%	0%

Nous devons souligner qu'aucune des alternatives n'est associée explicitement à l'utilisation d'un mode spécifique. La situation de référence pourrait cependant être associée au mode auquel elle correspond dans l'esprit de l'interviewé. Nous pouvons certainement supposer qu'une solution préférée à l'alternative de référence serait effectivement retenue si elle était possible sans changement de mode, mais nous ne pouvons en être certains, si elle nécessitait un changement. Afin de s'en assurer, une série de questions supplémentaires sont posées dans la dernière partie du questionnaire. Elles vérifient si le répondant aurait précédemment envisagé un changement, s'il y aurait des obstacles à cela, et s'il accepterait un changement au cas où une alternative préférée par rapport à la solution présente était réellement offerte alors même qu'elle impliquerait un changement de mode. Cette information supplémentaire devrait permettre de donner une interprétation des résultats obtenus par rapport à la problématique du changement modal.

Dans cet article nous ne pouvons pas encore tirer tous les enseignements de l'enquête. Le travail d'interprétation et d'analyse économétrique est toujours en cours, alors que diverses approches statistiques peuvent être suivies. Dans la section suivante, nous présentons seulement le modèle économétrique assez peu utilisé de Beggs et al. (1981) et Chapman et

Staelin (1982), mais qui est particulièrement bien adapté à l'analyse d'un classement par ordre de préférence. Ses résultats sont donnés et discutés dans la dernière section.

3. Le modèle logistique de choix appliqué aux rangements par ordre de préférence[4]

Les modèles de type logistique appartiennent à la famille des modèles de choix discret. Ces modèles visent à évaluer la probabilité de choisir une alternative parmi d'autres sur base de leur utilité qui est fonction du profil du décideur, des circonstances du choix ainsi que des caractéristiques des alternatives. Dans le contexte présent, il s'agit d'estimer l'importance relative d'un certain nombre d'attributs pour le choix d'une alternative de transport de marchandises. On pense en général que ce choix de solutions de transport se décide sur base de leurs « coûts généralisés », parmi lesquels sont compris tous les facteurs pertinents, y compris des facteurs qualitatifs pour ce qu'ils impliquent en termes de coûts pour la firme. Il vaudrait donc mieux parler ici de fonction de décision ou de fonction de coût plutôt que de fonction d'utilité. C'est pourtant cette terminologie qui est utilisée dans cet article car elle est la plus couramment utilisée.

L'objectif étant d'évaluer des fonctions exprimant l'utilité d'attributs de transport, il paraît opportun de ne considérer dans ces fonctions que les attributs par rapport auxquels les préférences individuelles ont été exprimées. Cependant, pour tenir compte des circonstances particulières des transports, telles la distance, la valeur des biens, le mode utilisé, etc., une série d'estimations par sous-groupes d'entreprises peut être effectuée. C'est la pratique la plus courante et c'est celle qui sera suivie dans cet article, quitte à examiner ultérieurement une autre modélisation. Le modèle économétrique utilisé ici correspond donc à une analyse logistique conditionnelle, développée initialement par McFadden (1974), dans laquelle les coefficients de chaque variable dans la fonction d'utilité sont communs à toutes les observations.

Le modèle de McFadden suppose que le décideur s'efforce de maximiser sa fonction d'utilité. Cependant cette maximisation est sujette à erreurs car le décideur peut avoir une perception imparfaite du problème et de son optimisation. De plus, certaines caractéristiques des alternatives peuvent n'avoir pas été observées. Pour ces raisons les fonctions d'utilité sont définies comme stochastiques avec des termes d'erreur caractérisés par une distribution

[4] Connu dans la littérature de langue anglaise sous le nom de « rank ordered logit ».

(doublement exponentielle) de Gumbel. Cependant, des données de rangements par ordre de préférence demande une spécification particulière du modèle qui a été développée par Luce (1959) et Luce et Suppes (1965) d'un point de vue théorique, et implémentée empiriquement par Beggs et al. (1981) et Chapman et Staelin (1982).

Le théorème du rangement par ordre de préférence de Luce et Suppes conduit à la décomposition suivante de la probabilité de classement :

$$\begin{aligned} P(1,2,...,J) &= P(1|\{1,2,...,J\}).P(2|\{2,3,\ldots,J\}) \\ &\quad \ldots P(J-1|\{J-1,J\}) \\ &= \prod_{j=1}^{J-1} P(j|\{j,j+1,\ldots,J\}). \end{aligned}$$

Dans cette équation, *P(1,2,…,J*) est la probabilité d'un rangement complet quelconque tel que l'alternative placée en première position (indexée par le chiffre 1), est préférée à l'alternative en seconde position (indexée par le chiffre 2), laquelle est préférée à l'alternative en troisième position, etc. Cette probabilité peut être décomposée en un produit d'une suite de probabilités *P(j | {j, j+1,…,J})*, qui correspondent aux probabilités que l'alternative *j* soit choisie plutôt que les autres alternatives contenues dans l'ensemble restreint allant de la position de préférence *j* à la dernière position *J*. L'équation signifie donc que la probabilité d'un rangement complet de *J* alternatives est égale au produit des probabilités de *J-1* choix indépendants faits par rapport à des ensembles de choix successivement réduits. Ce résultat résulte de l'hypothèse d'indépendance par rapport à des alternatives sans pertinence, qui déterminent des probabilités qui ne sont pas affectées par l'ordre de préférence des alternatives qui ne font pas partie de l'ensemble de choix.

Dans le cadre du modèle d'utilité stochastique, Beggs et al. (1981) arrivent à ce résultat à partir de la distribution des erreurs de Gumbel. En supposant que la fonction d'utilité est :

$$U_j = V_j + \epsilon_j = X_j'\beta + \epsilon_j = \sum_i \beta_i x_{ij} + \epsilon_j$$

avec la fonction de distribution cumulée

$$F(\epsilon_j < \epsilon) = exp(-e^{-\epsilon})$$

où j indique une alternative particulière et i initialise un attribut, on obtient que la probabilité d'un ordre de référence est le produit de probabilités de choix logistique par rapport à des ensembles de choix successivement réduits :

$$
\begin{aligned}
& Pr(u_1 > u_2 > \ldots > u_J) \\
&= \prod_{j=1}^{J} P(u_j > u_m, \forall m > j) \\
&= \prod_{j=1}^{J-1} \frac{\exp(V_j)}{\sum_{m=j}^{J} \exp(V_m)}
\end{aligned}
$$

La fonction de vraisemblance qui y correspond est :

$$
L(\beta) = \sum_{j=1}^{J-1} (V_j) - \sum_{j=1}^{J} \ln \left(\sum_{m=j}^{J} \exp(V_m) \right)
$$

La décomposition de la probabilité d'un ordre de préférence en un produit de probabilités de choix indépendants est qualifiée de processus d'explosion des données, qui permet une exploitation efficiente des données par la création d'observations de choix statistiquement indépendantes (Chapman et Staelin, 1982). Après cette démultiplication des données, l'estimation des fonctions d'utilité peut se faire comme une analyse logistique conditionnelle.

Notons bien que ce modèle doit être distingué du modèle de « rangement par ordre de réponse »[5] qui vise à estimer la probabilité qu'une alternative appartienne à une des catégories rangées selon un ordre de préférence. Cette approche exigerait l'estimation de paramètres supplémentaires qui définiraient le domaine des catégories.

4. L'analyse empirique

Comme expliqué en section 3, seuls les attributs sont introduits dans l'analyse économétrique[6], puisque les fonctions d'utilité individuelles ne dépendent que de ces variables. Les distributions de ces variables, aux valeurs qu'elles prennent pour les flux typiques, sont illustrées dans la Figure 1. On note que la Fréquence de service varie de 1 à 6, sans tenir compte du nombre de camions utilisés chaque jour, et que le Temps, ou durée du

[5] Connu sous le nom de « ordered reponse model » dans la littérature de langue anglaise (Maddala, 1991, p.46)
[6] Tous les calculs statistiques ont été effectués dans SAS, et le modèle « conditional logit » a été estimé au moyen de la procédure MDC.

transport, est majoritairement inférieur à 48 heures. La distribution de la Fiabilité est tassée vers 100% ; celle des Pertes en % des valeurs transportées, qui permettent de définir l'attribut de Sécurité (100 - % de perte), est tassée vers 0%. La Flexibilité a une moyenne élevée. Quant au Coût par tonne-km, il est rarement supérieur à 0,4. Les lignes pointillées dans chacun des diagrammes correspondent aux moyennes. Pour les alternatives hypothétiques introduites dans l'analyse économétrique, la valeur de leurs attributs est calculée en valeurs réelle en appliquant les pourcentages de variation sur la valeur de l'alternative de référence. Les attributs en pourcentage ne peuvent cependant dépasser 100% ni être inférieurs à 0%.

Evidemment, les fonctions d'utilité sont différentes d'une firme à l'autre selon les circonstances particulières à chaque firme. Pour en tenir compte, les données ont été réparties en sous-groupes sur base des distributions des données par rapport à plusieurs variables : le mode de transport, la distance de transport, la valeur et la catégorie des marchandises, l'unité de transport, ainsi que la disposition à changer de solution et de mode de transport. Des estimations successives par rapport à ces sous-groupes sont donc calculées. Les distributions des observations par rapport à ces variables sont illustrées dans la Figure 2 ci-dessous.

Par rapport aux modes, on a distingué les transports routiers (93 firmes), les transports par rail ou combinaison rail-route (9), les transports utilisant la voie navigable intérieure y compris en combinaison avec le rail ou la route (6) enfin les combinaisons de cabotage maritime avec la route et toutes autres combinaisons de modes (5). On voit donc que la majeure partie des interviews obtenues concernent des transports routiers.

Quant à la valeur des marchandises, trois groupes sont analysés : celui des marchandises de moins de 6 Euros/kg (63 firmes), celui des valeurs comprises entre 6 et 35 Euros/kg (33), enfin des valeurs plus élevées que 35 euros/kg (17).

Par rapport à la distance, les données ont été réparties en quatre groupes selon que les transports étaient d'une distance inférieure à 300 km (53 firmes), d'une distance comprise entre 300 et 700 km (28 firmes), entre 700 et 1.300 km (23 firmes), et au-delà (9 firmes).

La partition des données selon la catégorie de marchandises regroupent les expéditions de denrées alimentaires en catégorie 1 (14), les minéraux et matériaux, les engrais, les produits agricoles et produits pétroliers sont regroupés en catégorie 2 (17), les produits métallurgiques en catégorie 3 (10), les produits chimiques et pharmaceutiques en catégorie 4 (8), et finalement, en catégorie 5 se retrouvent les expéditions de produits divers (64).

Figure 1 : Distributions des attributs

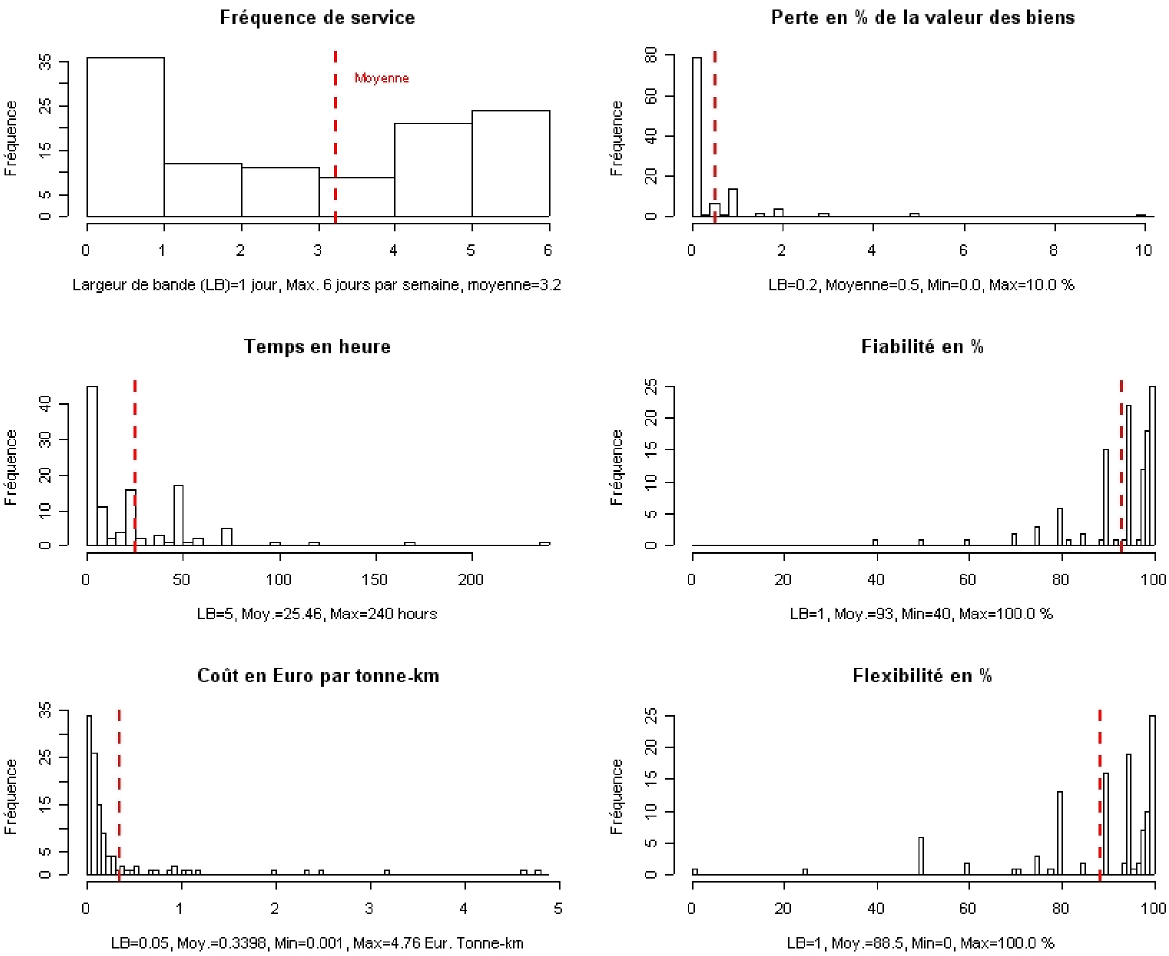
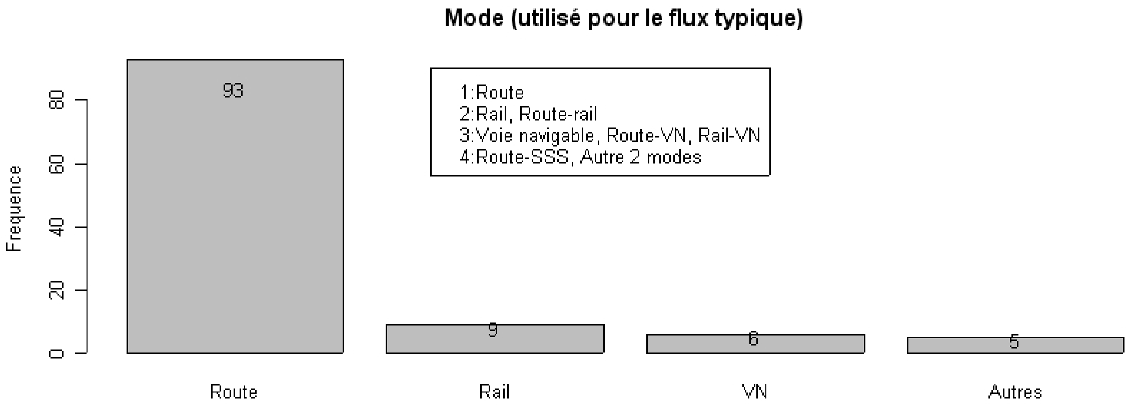
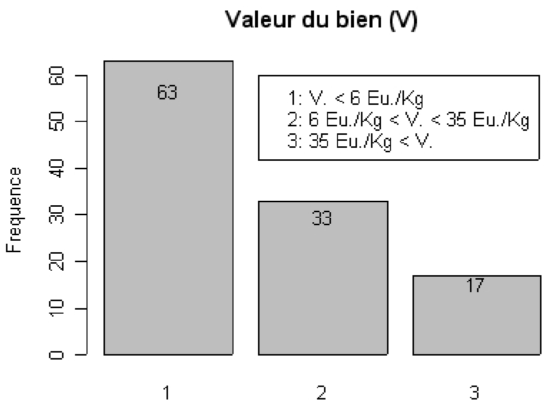
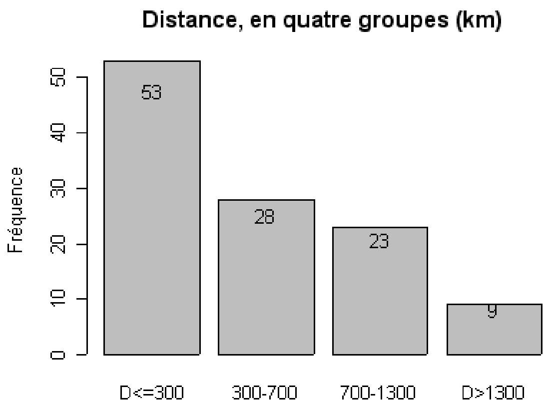
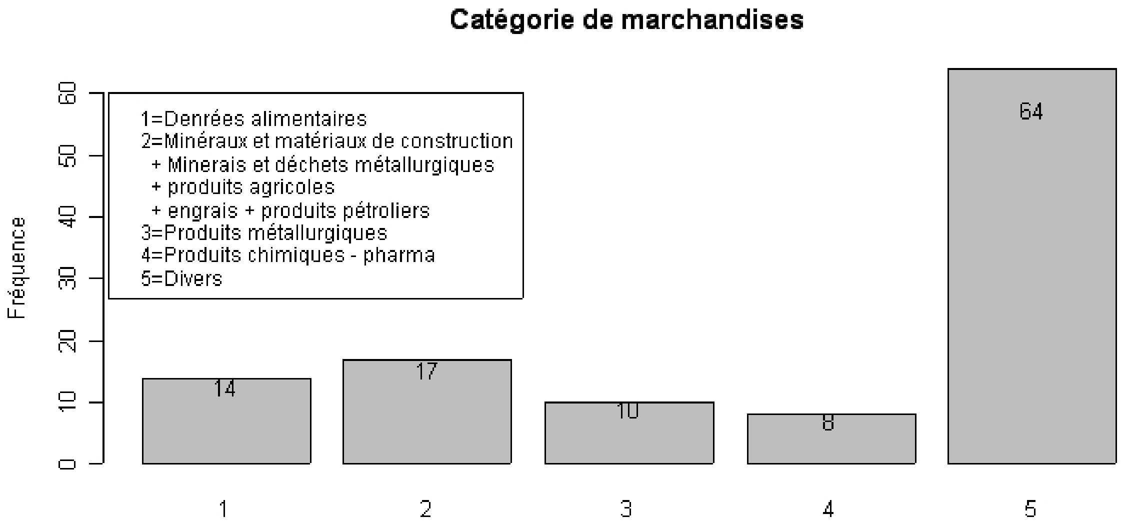


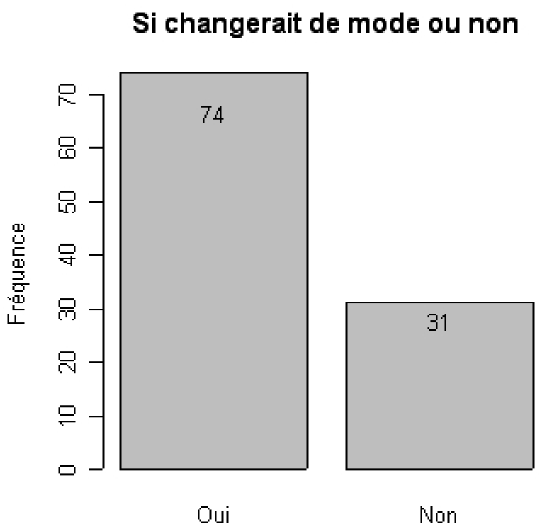
Figure 2: Distribution des variables de partition

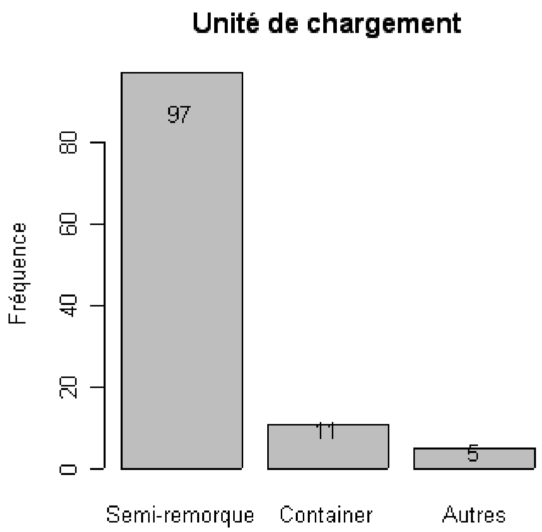












Les données ont aussi été partitionnées selon la disposition du gestionnaire de transport à changer (74) ou refuser de changer (31) de solution de transport même si cela implique un changement de mode.

Enfin, les trois catégories d'unité de chargement correspondent respectivement aux chargements conventionnels sur camions et semi-remorques (97), aux conteneurs (11), et aux chargements en wagons et sur des barges (5).

La première étape de l'analyse empirique consiste néanmoins en une estimation globale sur base de l'ensemble de l'échantillon. Les résultats en sont donnés par les deux premières lignes du Tableau 2. La première ligne donne le coefficient de chaque attribut dans la fonction d'utilité linéaire ; ensuite le nombre d'observations[7], le log de vraisemblance, et les valeurs des statistiques d'Estrella et de Kendall. La seconde ligne donne les valeurs de la statistique *t* affectant chaque coefficient. On voit donc que les six coefficients obtiennent les signes attendus (négatifs pour le Temps et le Coût, positifs pour les autres attributs), et sont bien significatifs. Le log de vraisemblance indique une relation globale significative. On note cependant, une statistique 'Estrella' assez faible[8]. Au-delà du biais habituel vers le bas résultant d'une application à des données de choix discrets individuels, la valeur réduite de cette statistique peut aussi résulter de l'hétérogénéité de l'échantillon. Le coefficient moyen de corrélation de rang de Kendall[9] est un autre indicateur qui mesure la corrélation entre un rangement de préférence observé et celui qui est estimé. Il indique ici un ajustement aux observations un peu meilleur. Toutefois, il témoigne également de l'hétérogénéité de l'échantillon, car sa valeur n'est que de 34%.

[7] Les nombres d'observations très élevés résultent du processus de décomposition des préférences. Pour obtenir (approximativement) le nombre d'interviews inclus dans un sous-groupe il suffit de diviser par 24.
[8] La statistique proposée par A. Estrella (1998) est assez semblable à la statistique mieux connue de McFadden, mais sa définition la rapproche davantage du traditionnel R^2. Sa définition est donnée en annexe.
[9] Sa définition est donnée en annexe. Ses valeurs correspondent ici à la moyenne des coefficients de Kendall calculés pour chacune des firmes d'un échantillon.

Tableau 2 : Estimation globale et par sous-groupes

Var.	Cat.		Fréqu	Temps	Fiabil	Flex	Sécurité	Coûts	Nbr obs.	Log Vrais.	Estrella	Kendall moyen
Global		Coefficient	0,129	-0,016	0,036	0,016	0,033	-3,259	2575	-5915	0,20	0,34
		t valeur	*3,498*	*-4,666*	*14,765*	*7,442*	*11,552*	*-11,682*				
Valeur	<6	Coefficient	0,130	-0,016	0,037	0,018	0,028	-7,026	1470	-3383	0,20	0,33
	Eu./Kg	*t valeur*	*2,785*	*-2,927*	*11,760*	*6,380*	*7,532*	*-8,487*				
	6 - 35	Coefficient	0,119	-0,015	0,043	0,017	0,028	-3,752	745	-1694	0,23	0,37
	Eu./Kg	*t valeur*	*1,605*	*-2,897*	*8,739*	*4,009*	*5,339*	*-7,269*				
	>35	Coefficient	0,146	-0,022	0,026	0,012	0,068	-2,025	360	-804	0,32	0,43
	Eu./Kg	*t valeur*	*1,429*	*-2,266*	*3,833*	*1,787*	*7,861*	*-6,391*				
Distance	<300	Coefficient	0,116	-0,050	0,042	0,019	0,031	-3,705	1207	-2736	0,23	0,37
		t valeur	*2,154*	*-3,435*	*11,094*	*5,879*	*7,388*	*-9,268*				
	300-700	Coefficient	0,195	-0,017	0,029	0,011	0,028	-1,733	624	-1460	0,15	0,28
		t valeur	*2,453*	*-2,524*	*6,292*	*2,393*	*4,974*	*-5,056*				
	700-	Coefficient	0,120	-0,010	0,036	0,013	0,037	-8,253	528	-1200	0,26	0,38
	1300	*t valeur*	*1,673*	*-2,180*	*6,386*	*2,719*	*5,783*	*-6,505*				
	>1300	Coefficient	0,069	-0,037	0,046	0,032	0,065	-22,932	216	-472	0,39	0,43
		t valeur	*0,455*	*-3,639*	*5,160*	*3,864*	*5,930*	*-6,000*				
Mode	Route	Coefficient	0,141	-0,034	0,037	0,019	0,034	-3,031	2095	-4790	0,22	0,35
		t valeur	*3,476*	*-5,279*	*13,616*	*7,551*	*10,624*	*-11,174*				
	Rail	Coefficient	0,066	0,000	0,072	0,009	0,017	-114,321	216	-454	0,49	0,57
		t valeur	*0,588*	*-0,085*	*7,581*	*1,273*	*1,859*	*-8,093*				
	VN	Coefficient	-0,291	-0,032	0,017	0,012	0,060	-560,149	144	-253	0,79	0,73
		t valeur	*-1,092*	*-3,649*	*1,665*	*1,161*	*4,414*	*-10,144*				
	Autres	Coefficient	0,186	-0,030	0,047	0,023	0,051	-10,410	120	-262	0,39	0,46
		t valeur	*0,995*	*-3,074*	*3,561*	*2,137*	*3,627*	*-4,909*				

Tableau 2 : suite

Var.	Cat.		Fréqu	Temps	Fiabil	Flex	Sécurité	Coûts	Nbr obs.	Log Vrais.	Estrella	Kendall moyen
Si chang. de mode	.	Coefficient	0,037	-0,061	0,062	0,008	0,021	-6,100	168	-377	0,30	0,54
		t valeur	*0,203*	*-1,635*	*5,466*	*0,954*	*1,964*	*-5,203*				
	Oui	Coefficient	0,124	-0,022	0,037	0,019	0,035	-4,145	1721	-3937	0,22	0,88
		t valeur	*2,863*	*-4,873*	*12,287*	*7,111*	*9,887*	*-8,727*				
	Non	Coefficient	0,166	-0,008	0,032	0,012	0,033	-2,254	686	-1586	0,18	0,41
		t valeur	*2,193*	*-1,493*	*6,853*	*2,735*	*5,981*	*-6,095*				
Catégorie de march.	Alimentaire	Coefficient	0,081	-0,046	0,065	0,029	0,021	-18,864	301	-641	0,43	0,50
		t valeur	*0,706*	*-2,165*	*7,834*	*4,481*	*2,492*	*-8,245*				
	Minéraux	Coefficient	0,132	-0,005	0,033	0,022	0,027	-3,505	396	-913	0,18	0,29
	...	*t valeur*	*1,532*	*-1,025*	*5,522*	*3,720*	*3,782*	*-4,622*				
	Métallurgie	Coefficient	0,128	-0,035	0,037	0,021	0,045	-74,669	240	-514	0,44	0,51
		t valeur	*0,864*	*-2,272*	*4,943*	*3,102*	*4,523*	*-7,661*				
	Chimie-	Coefficient	0,119	-0,031	0,049	0,011	0,040	-3,475	192	-424	0,35	0,44
	Pharma	*t valeur*	*0,976*	*-1,873*	*4,831*	*1,382*	*3,594*	*-5,130*				
	Autres	Coefficient	0,145	-0,023	0,035	0,016	0,035	-2,532	1446	-3332	0,19	0,33
		t valeur	*2,945*	*-4,403*	*10,465*	*5,274*	*9,289*	*-8,248*				
Unité de charge-ment 2	Semi-remorque	Coefficient	0,121	-0,018	0,039	0,018	0,032	-3,152	2191	-5011	0,22	0,35
		t valeur	*3,061*	*-4,592*	*14,396*	*7,407*	*10,258*	*-11,508*				
	Container	Coefficient	0,330	-0,015	0,029	0,014	0,059	-89,580	264	-557	0,48	0,54
		t valeur	*2,718*	*-1,585*	*3,934*	*2,036*	*5,895*	*-9,607*				
	Autres	Coefficient	-0,035	-0,030	0,051	0,005	0,044	-380,316	120	-219	0,74	0,67
		t valeur	*-0,150*	*-2,053*	*4,388*	*0,549*	*3,293*	*-9,373*				

Les estimations suivantes par sous-groupes obtiennent toutes un rapport de vraisemblance hautement significatif (tableau 3). Les valeurs 'Estrella' sont plus élevées. Ceci pouvait être attendu, puisque les groupes formés tendent à être plus homogènes. Les coefficients de Kendall sont également plus élevés. Par contre, si la plupart des coefficients sont bien significatifs, ceux des coefficients de l'attribut Fréquence sont souvent peu significatifs. D'autres coefficients sont peu significatifs dans les sous-groupes chemin de fer et voie navigable.

Tableau 3 : Test de rapport de vraisemblances

Variable	Test	p-valeur	Valeur seuil à 5% de confiance
Valeur	67,80	3,4516E-15	21,03
Distan	94,73	2,2578E-19	28,87
Mode	312,24	8,984E-132	28,87
Si chang. de mode	30,34	0,00118294	12,59
Catégorie de marchandises	182,99	3,0698E-48	36,42
Unité de chargement	255,54	5,505E-119	21,03

Test $= -2(L_{glob} - (L_1 + \cdots + L_i)) \approx \chi^2_h$

Cette partition de l'échantillon en sous-groupes ne résout certainement pas entièrement le problème de l'hétérogénéité des situations, car nous avons pu vérifier qu'une application directe du modèle à des ordres de préférence individuels livrait souvent des corrélations de rang bien supérieures, de l'ordre de 70% pour certaines firmes. Quoiqu'il en soit, ces partitions et l'interprétation que l'on peut faire de leurs résultats montrent clairement combien les jugements peuvent différer selon les circonstances des envois et des firmes.

Les tableaux 4 et 5 suivants permettent le mieux cette interprétation par la mise en exergue de la signification de chaque coefficient. En effet, le Tableau 4 donne les poids pris par chaque attribut pour le choix d'une solution de transport selon les différents groupes de firmes. Ces poids sont calculés sur base des variations des attributs dans chaque groupe (voir la définition en annexe). Considérant la première ligne du tableau, qui se réfère à l'échantillon global, on voit combien le Coût joue un rôle dominant dans la décision, car son poids est de 63,7 %. Le temps vient en second ordre d'importance avec un poids de près de 16 %. Le troisième facteur important est la Fiabilité avec un poids global de 8.5 %. Viennent ensuite la Flexibilité (5,6 %), la Fréquence (3,16 %) et la Sécurité (3,15 %).

Toutefois, de fortes variations apparaissent à nouveau lorsque l'on considère les résultats par sous-groupes. Certes, le Coût reste le facteur dominant et obtient toujours un poids supérieur à 54 %, mais la Fiabilité peut prendre le pas sur le Temps de transport dans quelques cas et surtout pour les expéditions par chemin de fer. Par contre, la Fiabilité n'a qu'un rôle réduit pour la voie navigable et les autres combinaisons de transport. De façon plus générale, on observe des variations de poids non négligeables d'un groupe à l'autre.

Une autre façon d'interpréter les résultats est de calculer les valeurs monétaires équivalentes des différents attributs. Ainsi qu'on le sait, ces valeurs peuvent être simplement calculées pour chaque attribut qualitatif par le rapport de son coefficient à celui du coût de transport. Elles mesurent les montants monétaires maxima par tonne-km ou par tonne que les firmes pourraient être prêtes à payer pour obtenir une meilleure qualité de service, par exemple un transport plus rapide ou une fiabilité plus grande. Réciproquement, elles mesurent le coût pour les firmes d'une détérioration de la qualité, c'est-à-dire la réduction de tarif qu'elles pourraient vouloir exiger. Ces valeurs sont présentées dans le Tableau 5.

Il faut noter que, à la différence des poids présentés dans le Tableau 4, les valeurs monétaires des différents attributs ne peuvent pas être vraiment comparées, car elles se réfèrent à des attributs définis en unités non comparables. En effet la valeur d'une variation du nombre d'heures ne peut être comparée en valeur à celle de la variation du pourcentage de fiabilité. Ceci dit, on voit dans le Tableau 5 que ces valeurs par tonne-km varient fortement d'un groupe à l'autre. Les valeurs les plus basses et proches de zéro sont données par des firmes qui utilisent la voie d'eau, c'est-à-dire le mode 3, sauf pour la valeur du Temps, qui est encore légèrement plus basse pour le chemin de fer. A vrai dire, de ce point de vue, il n'y a pas grande différence entre ces deux modes. La valeur la plus élevée pour la Fréquence est de 0,1123 € pour des distances comprises entre 300 et 700km, celle de la Fiabilité atteint 0,0167 € pour la même catégorie, celle de la Flexibilité vaut 0,0063 € pour les marchandises diverses, celle de 1a Sécurité atteint 0,0335 € pour des marchandises de haute valeur, tandis que la valeur du Temps atteint 0,0134 € pour les distances les plus courtes.

Tableau 4 : Poids des attributs selon les partitions

Modèle		Fréqu	Temps	Fiabil	Flex	Sécurité	Coûts
Global		3,16%	15,92%	8,47%	5,63%	3,15%	63,67%
Valeur	<6 Eu./Kg	3,12%	10,72%	6,48%	6,16%	2,27%	71,25%
	6-35 Eu./Kg	2,70%	13,55%	9,31%	4,27%	2,47%	67,70%
	>35 Eu./Kg	5,59%	13,88%	4,16%	3,90%	9,18%	63,29%
Distance	<300	2,79%	9,48%	8,36%	6,38%	2,32%	70,67%
	300-700	8,11%	20,08%	6,89%	3,77%	3,97%	57,18%
	700-1300	2,07%	6,97%	6,18%	1,98%	2,61%	80,19%
	>1300	2,64%	19,99%	8,92%	6,95%	7,27%	54,23%
Mode	Route	3,90%	11,21%	8,64%	5,80%	3,64%	66,81%
	Rail	2,13%	0,62%	24,41%	2,73%	2,10%	68,01%
	VN	6,11%	21,57%	2,25%	4,19%	4,51%	61,38%
	Autres	5,56%	18,28%	5,21%	6,38%	4,98%	59,59%
Si	.	2,25%	15,65%	16,03%	4,52%	4,01%	57,53%
changement	Oui	2,56%	13,31%	5,71%	5,70%	2,86%	69,86%
	Non	7,57%	13,87%	13,68%	5,89%	4,35%	54,65%
Catégorie	Alimentaire	1,89%	8,87%	6,48%	4,04%	1,58%	77,14%
de	Minéraux ...	5,19%	8,25%	12,47%	12,26%	3,27%	58,56%
marchandises	Métallurgie	2,10%	6,89%	4,07%	2,52%	2,51%	81,91%
	Chimie-Pharma	3,16%	6,65%	9,75%	2,18%	3,05%	75,21%
	Autres	4,60%	14,40%	9,19%	5,60%	4,34%	61,88%
Unité de	Semi-remorque	2,99%	17,81%	9,17%	4,97%	3,04%	62,02%
chargement	Container	9,92%	7,55%	5,02%	3,48%	5,26%	68,76%
	Autres	0,93%	6,54%	9,37%	2,74%	4,68%	75,75%

Pour la valeur du Temps, qui a fait l'objet de nombreuses études avec des résultats variés, sa valeur a aussi été calculée par tonne pour les transports de distance médiane de chaque sous-groupe. On voit ainsi que les firmes qui utilisent le chemin de fer ne seraient disposées à payer que 0,004 € par tonne pour gagner une heure de temps pour un transport de 991 km. Par contre, pour des marchandises de haute valeur, les firmes seraient prêtes à payer 6.89 € en plus par tonne pour gagner une heure sur un parcours de 650 km. La valeur du Temps attribuée aux transports par route s'élève à 3,102 € par tonne sur une distance moyenne de 277 km.

Pour obtenir les valeurs par tonne des autres attributs pour un transport moyen, il suffit de multiplier les coefficients de ce tableau par la distance médiane du transport. Ainsi, les chargeurs utilisant la route seraient donc prêts à payer (277 x 0,0123) = 3,41 € par tonne pour un pour-cent d'augmentation de la Fiabilité, 12,85 € pour un jour de plus de Fréquence de service, et 3,08 € pour une sécurité augmentée d'un pour-cent. Des calculs semblables peuvent être faits à partir du Tableau 5 pour les autres sous-groupes analysés.

Tableau 5: Valeurs des attributs de transport

Var.	Cat.	Fréqu (par jour)	Fiabil (par point de %)	Flex (par point de %)	Sécurité (par point de %)	Temps en €par tonne-km par heure	Temps en €par tonne par heure pour la dist. méd.	Distance médiane (en Km)	Taille médiane d'envoi (en Tonne)	Temps médian
Global		0,0394	0,0112	0,0051	0,0101	0,0050	1,590	320	20	11
Valeur	<6 Eu./Kg	0,0185	0,0052	0,0026	0,0040	0,0022	0,696	310	24	6
	6 - 35	0,0316	0,0116	0,0045	0,0074	0,0040	1,006	253	13	19
	>35	0,0721	0,0130	0,0057	0,0335	0,0106	6,902	650	18	24
Distance	<300	0,0313	0,0113	0,0052	0,0084	0,0134	1,627	121	20	3
	300-700	0,1123	0,0167	0,0061	0,0160	0,0097	4,196	433	20	11
	700-1300	0,0146	0,0043	0,0016	0,0045	0,0012	1,088	900	20	48
	>1300	0,0030	0,0020	0,0014	0,0028	0,0016	2,248	1386	15	48
Mode	Route	0,0464	0,0123	0,0062	0,0111	0,0112	3,095	277	19	6
	Rail	0,0006	0,0006	0,0001	0,0002	0,0000	0,004	991	28	48
	VN	0,0005	0,0000	0,0000	0,0001	0,0001	0,009	151	725	48
	Autres	0,0179	0,0045	0,0022	0,0049	0,0029	2,899	1015	19	72
Si chang.	.	0,0060	0,0101	0,0014	0,0035	0,0101	2,090	208	21	14
de mode	Oui	0,0299	0,0090	0,0047	0,0084	0,0054	1,859	343	20	13
	Non	0,0738	0,0141	0,0052	0,0147	0,0034	1,289	380	19	11
Catégorie	Alimentaire	0,0043	0,0035	0,0016	0,0011	0,0024	0,449	185	15	3
de march.	Minéraux ...	0,0377	0,0093	0,0062	0,0078	0,0015	0,180	123	25	4
	Métallurgie	0,0017	0,0005	0,0003	0,0006	0,0005	0,218	468	25	13
	Chimie-Pharma	0,0342	0,0142	0,0032	0,0115	0,0089	2,611	294	13	25
	Autres	0,0574	0,0137	0,0063	0,0139	0,0090	3,994	443	19	24
Unité de	Semi-re.	0,0382	0,0124	0,0057	0,0100	0,0057	1,716	301	20	8
chargement	Conteneur	0,0037	0,0003	0,0002	0,0007	0,0002	0,150	876	24	24
	Autres	0,00009	0,00013	0,00001	0,00012	0,00008	0,031	400	1000	48

* Les valeurs pour chaque attribut qualitatif sont les quotients de leurs coefficients (Tableau 2) par rapport à celui du coût.

5. En guise de conclusion.

A ce stade de notre recherche, il nous paraît clair que l'importance et la valeur qu'un gestionnaire de transport peut attribuer à une caractéristique d'un transport, sa fiabilité par exemple, dépend d'un grand nombre de facteurs, la nature de la marchandise, sa valeur, la distance, la logistique interne et externe de l'entreprise, etc. La variété des résultats obtenus ci-dessus, tout comme l'analyse d'un certain nombre de cas individuels, témoigne de cette hétérogénéité.

Ceci explique aussi la grande dispersion des résultats obtenus et publiés dans la littérature scientifique, par exemple parmi ceux rassemblés par de Jong et al. (2000 et 2004). Certes, une partie de cette dispersion s'explique par des différences méthodologiques. Toutefois, les échantillons analysés diffèrent aussi d'une étude à l'autre. D'une part, en transport de marchandises, la difficulté de rassembler des échantillons suffisamment larges en analyse de préférences déclarées est bien connue, en sorte que les échantillons souvent ne sont pas aussi larges que souhaités. D'autre part, et plus fondamentalement, les transports repris dans les divers échantillons se différencient fortement par leurs caractéristiques, c'est-à-dire la distance parcourue et la destination, le tonnage transporté, la marchandise et sa valeur, la configuration du réseau parcouru, et les entreprises elles-mêmes. Il n'est donc pas surprenant que l'on obtienne des valeurs assez différentes d'une étude à l'autre.

Malheureusement, ces constatations ne sont pas de nature à faciliter la tâche de l'analyste qui voudrait introduire des valeurs du temps, de la fiabilité, etc. dans une étude de trafics, par exemple. Plutôt que d'introduire des valeurs moyennes, il conviendrait de recourir à des distributions de valeurs, ce qui n'est pas simple à estimer. Dans une certaine mesure, des résultats (moyens) par catégorie de marchandises, par distance, ou par valeurs, comme calculés ci-dessus, pourraient résoudre une partie du problème.

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Annexe

- Formule de Estrella

$$R_{E1}^2 = 1 - (\frac{L}{L_0})^{-\frac{2}{N}L_0}$$

où L_0 est le log de la vraisemblance calculé avec tous les paramètres fixés à zéro.
Bien que cette statistique soit comprise entre les valeurs extrêmes de 1 et 0, elle tend à être assez réduite, comme d'ailleurs la statistique de McFadden et le R^2, dans les cas d'estimation de probabilités calculées sur des données individuelles de choix discrets. Sur sa signification dans ce contexte, voir J.S. Cramer (1991, Ch.5).

- Formule de Kendall

Le coefficient de corrélation de rang de Kendall est produit à partir de la procédure CORR de SAS. C'est une mesure d'association entre un rangement observé et un rangement prédit. Le taux est calculé pour un nombre *n* de paires *(X ,Y)* comme le nombre de paires concordantes *(Nc)* moins le nombre de paires discordantes *(Nd)*, divisé par le nombre total de paires.

$$\tau_K = \frac{(Nc - Nd)}{[n(n-1)/2]}$$

Comme un coefficient de corrélation usuel, il varie entre -1, pour une corrélation parfaitement inverse, et +1 pour une corrélation de rang parfaite. Pour cette recherche, ce coefficient est calculé séparément pour chaque firme appartenant à un même groupe; la moyenne des coefficients individuels est ensuite calculée.

- Formule des poids.

Etant donné une fonction d'utilité

$$U = \sum_{i=1}^{6} \beta_i x_i$$

le poids pour chaque critère (attribut) j, j=1, …, 6 est

$$w_j = \frac{|\beta_j|(x_j^* - x_{*j})}{\sum_{i=1}^{6} |\beta_i|(x_i^* - x_{*i})}$$

où x_j^* et x_{*j} sont respectivement les valeurs maximum et minimum de la variable.

Analyzing freight transports' qualitative attributes from stated orders of preference

Abstract

The research aims at estimating the relative importance and value for freight shippers of qualitative factors that characterize transport solutions: service frequency, transport time, reliability of delivery, carrier's flexibility, and safety. A stated preference experiment with a set of transport managers provided a sample of preference orders among a set of hypothetical transport solutions. A conditional logit model adjusted for handling preference orders (Beggs et al., 1981) is applied to the global sample, but also to sub-samples classified according to the transport distance, the goods' value, etc. This analysis shows that different qualitative factors play important and differentiated roles in the choice of a transport solution, and that their relative importance varies according to the categories of firms and transports.

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1. Introduction[1]

In the context of a continuous expansion of transport flows, and particularly of road transports with their negative external impacts, European public authorities have devised a transport policy that calls for the substitution of public transports to private cars and the promotion of freight transports by rail and inland waterways rather than by trucking. Considering only the problems of freight transport in this paper, some useful partial information may be available about transport price direct- and cross- elasticities, for instance in Abdelwahab (1998), NEI (1999) and Beuthe and al. (2001). However, the problem of transportation choice cannot be reduced to the one of pricing but should also encompass the role of qualitative factors, which may bear upon the internal and external logistic organisation of the firms. Thus, in order to examine the real potential of a modal switch strategy, it is necessary to well understand all the factors that determine transport choices, including the service quality characteristics of the various transport solutions, i.e. factors like reliability of delivery, service frequency, absence of losses, transport time (or speed), and carriers' flexibility in reaction to unexpected demands. These are factors that are not sufficiently taken into account in the above studies.

The present paper wishes to contribute to a better understanding of the relative importance and value of freight transports' qualitative attributes by the analysis of a stated preference experiment on hypothetical transport solutions, which has been realised with Belgian transport managers. Every economic analyst certainly would prefer a revealed preference approach based on choices made among real alternatives. However, in most cases and certainly in Belgium, this approach is not feasible for lack of data.

Thus, over the last few years, this useful methodology has been applied to freight transports in a variety of contexts and with contrasting results. The various methodologies of survey and the different econometric methods play some role in this diversity. However, the relative importance of decision factors is also be influenced by the circumstances of transports, i.e the nature and the value of the goods, the distance, the shipment sizes, the configuration of the network, etc. This is an aspect that we have tried to highlight in our analysis, by providing estimates for various sub-groups of firms. Naturally, these two reasons, plus the incomplete information about data given in published literature, make a reasonable comparison between studies extremely difficult.

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[1] This paper is one output of a research led by a Belgian consortium directed by M.Beuthe (Catholic University of Mons), H.Meersman and E.Van de Voorde (University of Antwerp), M. Mouchart (Catholic University of Louvain), and F.Witlox (University of Ghent). We thank the Belgian Federal Office for Scientific, Technical and Cultural Affairs (OSTC) for the financial support it granted to this project.

In this context of analysis, Section 2 of the paper gives a short description of the questionnaire developed for this research and the experimental design that is used to elicit an order of preference among transport solutions from transport managers. Section 3 presents the econometric modelling applied to that type of data. Section 4 presents and comments the empirical results obtained in terms of transport attributes' weights in decision making, as well as the monetary equivalent values of the qualitative attributes. Also, a comparison with other studies' published results is attempted. Finally, in Section 5, we present some concluding comments.

2. The Questionnaire and Stated Preference Experiment

Stated preference techniques are currently used in the field of transport economics for analysing transport choices made by travellers and freight shippers. Much information about this field of enquiry and techniques can be found, for instance, in the recent Manual published by the U.K. Department of transport (2002). Over the last few years, some researches using that methodology have also been published in the field of freight transportation, and some recent contributions certainly deserve to be mentioned here: Fowkes and Shingai, Bolis and Maggi, Fridstrom and Madslien, Maier and Bergman, all of them edited in the book by R Danielis (2002), but also Danielis et al. (2005), Bergkvist (1998), Jovicic (1998), NERA (1997), STRATEC (1999), INRETS (2000), Garcia-Menendez et al. (2004), de Jong (2000) and de Jong et al. (2004) to name just a few. However, most of them limited their research to very specific transport alternatives, like the choice between trucking and rail inter-modal transport along a corridor, the choice between an external carrier and own-transport, or they simply focused on the value of time. Moreover, samples are sometimes rather (very) small given the number of potential explanatory variables. Altogether, more research in this field is needed, particularly in the transport context of Belgium where no wider scope study has ever been made. These are the reasons that determined our involvement.

The stated preference data used in this paper are taken from a survey of Belgian freight transport managers. The survey methodology and the questionnaire are based on an extensive survey of the transport, marketing and statistical literature in the field. Besides the contributors mentioned in the introduction, we should also cite Green and Srivinisan (1990), Huber et al. (1996), Louvière et al. (2000), as well as Oppewal (1995 a and b), and Carroll and Green (1995) for reviews of techniques and available software. Additional references can be found in the survey paper by Louvière and Street (2000), as well as in the Manual of the U.K Department of Transport (2002).

Some preliminary in-depth interviews of transport managers were made in the course of preparing the questionnaire. Its feasibility was then pre-tested and adjusted accordingly. In the end, it is a compromise between a desire to gather as much useful information as possible and practical considerations. The choice of face-to-face interviews was made because it allowed the gathering of additional information in the course of the dialogue with the interviewee, and opened the possibility of easing the interviewee's task. The questionnaire and the stated preference experiment were administered on paper without any computer support.

Previous studies on freight transport considered four to seven different attributes among which we identified and defined six relevant attributes. This number is still considered as feasible for handling an interview. Since the purpose is to identify the attributes' relative importance in decision making, a full profile presentation of the six attributes characterizing each transport alternative was deemed appropriate. For easing the task, we chose to present each alternative on a separate card; this conveniently permits to compare and rank all the alternatives, with the possibility of changing one's mind in the course of the interview. We also chose to demand only a full ranking of all alternatives, with no rating of preferences. Indeed, a ranking already provides a very rich information about the respondent's preference system. In addition, the number of alternatives was determined by a fixed orthogonal fractional factorial design of 25 alternatives, as proposed by Addelman (1962). Altogether, this task was deemed acceptable to most of the people interviewed. Note that this experimental design implies that only the attributes' main effects on preferences can be analysed, whereas the effects of two attributes interaction are left aside.

The target population of the survey is the Belgian shippers of freight, which have at least 20 employees, in all industries and to any destination in Europe. Included among respondents are logistic operators and forwarders who manage shipments for industry. The modes of concern are: rail, road, waterway, short-sea-shipping, and their inter- and multi-modal combinations. Given the small size of the country, no location of origin is excluded, even though some modes may have a reduced accessibility like inland navigation in some provinces. Focusing on possible modal shifts, urban and distribution activities on short distances are excluded. Although there is a reduced opportunity over short distances for non-road transports, no minimum transport distance is set for the survey, since there are important cases of industrial goods that are transported over short distances by rail or inland navigation.

Unhappily, for a variety of reasons, firms are often reluctant to be interviewed, so that, like in other similar studies, we were unable to gather a large sample: from about 600 firms that were contacted by telephone and/or by mail, only 113 accepted an interview and provided usable information. Thus, our sample cannot be taken as representative of the whole range of transport situations in Belgium, despite the fact that it approximately respects the observed distribution of modes as well as the firms' revenue distribution in Belgium. Nevertheless, a detailed analysis of the sample as presented in this paper provides a number of useful results that put to the fore the wide spread of transport managers' attitudes and values with respect to the quality attributes of transports. The sample characteristics will be further detailed in Section 4 of the paper.

The face-to-face interviews are based on a questionnaire made of four parts: first, general questions about the characteristics of the firm and its transport organisation; second, the description of a typical transport shipment to be used as reference in the stated preference experiment; third, the stated preference experiment itself that aims at eliciting the relative importance of the quality attributes; fourth, a set of questions about the transport manager's readiness to accept a modal switch.

The questions about a typical transport shipment flow from the firm's plant concern: the specific good and its characteristics, its origin and destination, the transport distance, the flow's annual tonnage, the shipments size and frequency, the type of consignee, etc. Then, the typical flow must be defined in terms of six transport attributes:

- COST, as out-of-pocket cost for transport, including loading and unloading;
- TIME, as door-to-door transport time, including loading and unloading;
- LOSS as the % of commercial value lost from damages, stealing and accidents;
- FREQUENCY of service per week actually supplied by the carrier or the forwarder;
- RELIABILITY as the % of deliveries at the scheduled time;
- FLEXIBILITY as the % of times non-programmed shipments are executed without undue delay.

In order to encompass the idea of probability or risk, some criteria are defined in percentage of occurrences.

In the central part of the interview, the respondent is asked to rank according to his/her preferences various transport alternatives defined by the six attributes in a full profile representation. Each alternative is defined by the six attributes' percentage variations from the chosen typical flow's current transport solution, and each alternative is conveniently presented on a separate card. This set-up allows the use of the same set of alternatives and cards for all respondents even though their reference flow is different. Nevertheless, the respondent is invited to keep in mind the analyzed typical flow and to interpret the percentage variations in terms of that reference situation (Department for Transport, 2002, Ch.12). Some examples of alternatives in percentages are shown in Table 1.

Only five levels of variation are considered: plus or minus 10%, and plus or minus 20% with respect to the status quo reference level at a 0% variation. In Table 1, alternative 1 obviously corresponds to the current transport solution. In contrast, alternative 2 is characterized by a 10% increase of both transport time and reliability, a 20% increase of flexibility, a 10% decrease of loss and a 20% cost decrease. For example, this means that, if the cost of a reference typical flow is 100 EURO and its reliability is at the level of 70%, the cost of alternative 2 is only 80 EURO and its reliability improved at the level of 77%. The face-to-face interviews provide the opportunity to carefully explain the experiment's set-up and to answer to the interviewee's questions 2.

Table 1: Some Examples of Full Profile Alternatives

	Frequency	Time	Reliability	Flexibility	Loss	Cost
1	0%	0%	0%	0%	0%	0%
2	0%	10%	10%	20%	-10%	-20%
3	0%	20%	20%	-20%	10%	-10%
4	0%	-10%	-10%	10%	-20%	20%
5	0%	-20%	-20%	-10%	20%	10%
6	10%	0%	10%	10%	10%	10%
-	-	-	-	-	-	-
15	20%	-20%	10%	0%	-20%	-10%
16	-10%	0%	-10%	-10%	-10%	-10%
17	-10%	10%	-20%	0%	10%	20%
-	-	-	-	-	-	-
23	-20%	20%	10%	-10%	0%	20%
24	-20%	-10%	20%	0%	-10%	10%
25	-20%	-20%	-10%	20%	10%	0%

2 In some cases, the reference solution may very well have an attribute with value close or equal to 100% (or 0%). This would impose a constraint on a positive percentage variation (or a negative one). If needed, this is also explained to the decision maker.

It is worth underlining that none of the alternatives is explicitly characterised by a specific mode, whereas the reference solution may very well be associated with its actual mode in the respondent's mind. Clearly, it can be presumed that a preferred hypothetical alternative would be chosen if it were really available without any modal switch, but, if a modal switch was needed the decision maker might very well prefer to stick to its present solution. In the last part of the questionnaire, additional questions focus on that problem. They investigate whether the respondent has ever considered switching mode, whether there would be obstacles to do so, and whether he/she would actually switch mode if a better was available. This additional information will permit a more precise interpretation of the stated preference data with respect to the modal choice by the decision maker.

The reader may have noted that this approach, based on hypothetical alternatives that are not characterized by a mode, is akin to an 'abstract mode' approach. It follows that it will not be possible, like Garcia-Menèndez et al.(2004) for instance, to estimate any elasticity of the probability of choosing a specific mode. Nevertheless, as will be explained below, it is still possible to extract from the results a measure of the relative importance of each attribute in decision making by computing the relative average weight that each attribute takes in the utility function.

3. The rank ordered logit model

This discrete choice model is based on the model developed by McFadden under the hypothesis that the decision maker maximizes her/his expected utility function, which is characterized by Gumbel distributed random errors. In its conditional version, the variables' coefficients are common to all observations. In the present case, it aims at estimating the probability of choosing a transport solution among a set of alternatives. This probability is assumed to be a logistic function of the decision maker's utility, the latter being a linear function of the transport alternatives attributes. In general, it is rather thought that the choice of a freight transport solution is made on the basis of the transport « generalized cost », which includes the price paid to the carrier but also all other relevant qualitative factors in their equivalent monetary values for the shippers. Hence, it would be more appropriate to talk about a decision or cost function rather than a utility function. This terminology is nevertheless maintained in this section as it is the conventional one in the field.

The decision makers' utility is taken here to be a function of only the six attributes defined in the previous section, because the gathered data refer to preferences stated with respect to these six attributes only. However, some estimates will be computed for different sub-groups of firms in order to take into account the special circumstances of some transports: the distance, the value of the goods, the mode, etc.

However, the handling of rank ordered data requires a particular specification of the conditional logit model, which has been proposed by Luce (1959) and Luce and Suppes (1965), and implemented by Beggs et al. (1981) and Chapman et Staelin (1982).

The Luce and Suppes's theorem on preference ranking leads to the following decomposition of the probability of a ranking:

$$\begin{aligned} P(1,2,...,J) &= P(1|\{1,2,...,J\}).P(2|\{2,3,\ldots,J\}) \\ &\quad \ldots P(J-1|\{J-1,J\}) \\ &= \prod_{j=1}^{J-1} P(j|\{j,j+1,\ldots,J\}). \end{aligned}$$

In this equation, $P(1,2,\ldots,J)$ is the probability of a complete ranking such that the most preferred alternative is ranked 1, the second best alternative is ranked 2, the third best alternative is ranked 3, etc., whereas $P(j \mid \{j, j+1,\ldots,J\})$ is the probability that alternative j is preferred rather than any other alternative included in the reduced set containing alternatives from the j^{th} preference position to the least preferred alternative. Thus, the equation means that the probability of a complete ranking of alternatives can be equated to the product of $J-1$ independent probabilities of choices, which are made with respect to successively reduced sets of alternatives. This theorem is the result of the usual hypothesis of independence with respect to irrelevant alternatives.

In the framework of the random utility model, Beggs et al. obtain the same result under the assumption that the random errors are Gumbel distributed. Thus, assuming the following utility function:

$$U_j = V_j + \epsilon_j = X_j'\beta + \epsilon_j = \sum_i \beta_i x_{ij} + \epsilon_j$$

with the cumulative distribution

$$F(\epsilon_j < \epsilon) = exp(-e^{-\epsilon})$$

where j indicates a particular alternative and i refers to a specific attribute, the probability of a preference ranking is the product of successive logistic choice probabilities with respect to successively reduced choice sets :

$$Pr(u_1 > u_2 > \ldots > u_J) = \prod_{j=1}^{J} P(u_j > u_m, \forall m > j) = \prod_{j=1}^{J-1} \frac{\exp(V_j)}{\sum_{m=j}^{J} \exp(V_m)}$$

The corresponding likelihood function is

$$L(\beta) = \sum_{j=1}^{J-1} (V_j) - \sum_{j=1}^{J} \ln \left(\sum_{m=j}^{J} \exp(V_m) \right)$$

This breaking down in parts of a preference ranking probability leads to what is sometimes called a process of data explosion, which allows an efficient use of the data by the creation of statistically independent observations (Chapman et Staelin, 1982). Given this data multiplication, the utility function can be estimated along the lines of the conditional logit analysis.

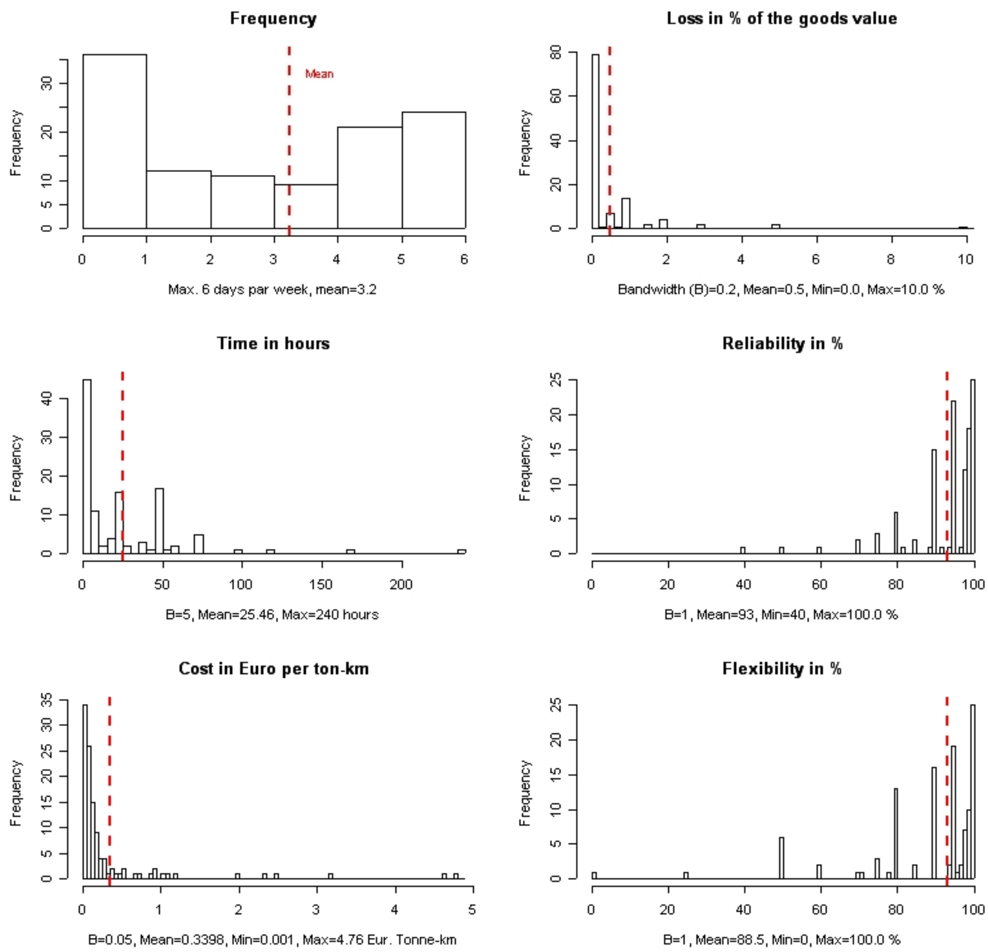
It is worth noting that this « rank ordered data model » must be distinguished from the « ordered response model » (Maddala, 1991), which aims at estimating the probability that an alternative belongs to one among a set of categories ranked according to a preference order. Such an approach would require an estimation of a number of additional parameters defining each category domain.

4. Empirical analysis

As explained earlier, only the attributes are included in the utility function, since the individual utility functions depend on these variables. The distributions of these variables over the typical reference transports are illustrated in Figure 1. Note that the Frequency of service varies from 1 to 6, without taking into account the number of trucks per day, and that the transport Time is generally lower than 48 hours. The distribution of Reliability is squeezed up close to 100%, whereas the distribution of losses in percentages, which allow the definition of Safety (100 - % of losses), is squeezed down to 0%. Flexibility has a rather high average. The Cost per tonne-km is rarely higher than .4. The dotted lines indicate the average values. The hypothetical alternatives' data are introduced in the econometric analysis at their real values computed by applying the percentages of variation in Table 1 on the reference levels. However, the attributes defined in percentage cannot have value beyond 100% or lower than 0%.

It is clear that the utility functions of different firms may not be similar, given the special circumstances of each firm, i.e. the goods they ship, their value, the distance of transport, etc. Hence, the data have been partitioned in sub-groups taking into account the distributions of some relevant variables: the transport mode, the distance, the value and category of transported goods, the loading unit and the willingness to switch mode. The data distributions according to these partitions are given in Figure 2.

Figure 1: Distributions of attributes

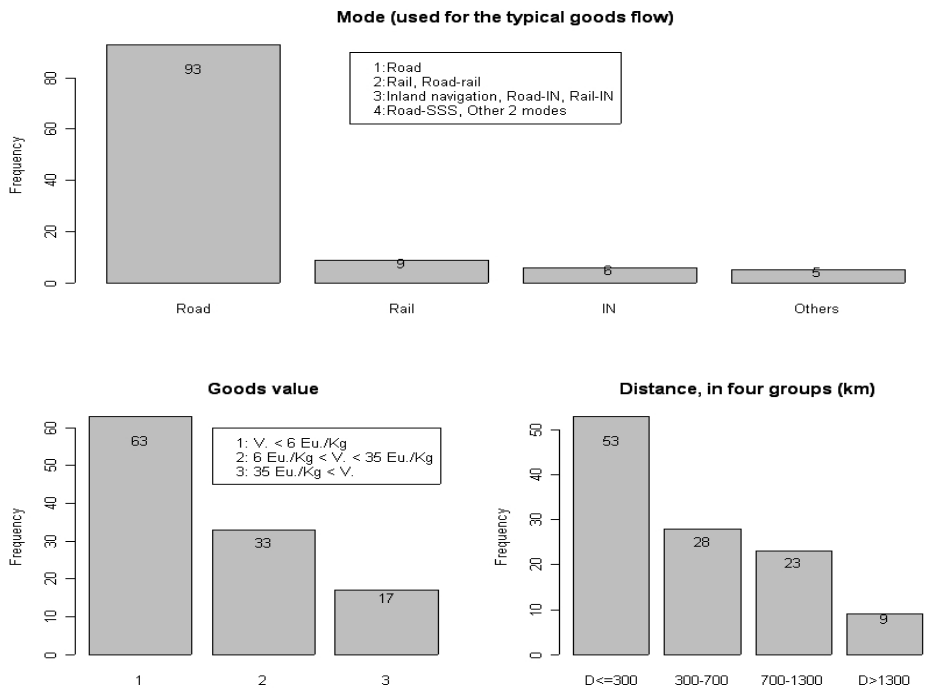


With respect to modes, four groups are distinguished: road trucking (93 firms), rail or road-rail transports (9), inland waterway transports including combinations with rail or road (6), and combinations of short-sea shipping with other modes (5).

As to the values of the goods, three groups are distinguished: values of less than 6 Euro/kg (63 firms), values between 6 and 35 Euro/kg (33), and values above 35 Euros (17).

With respect to transport distance, the data were divided in four groups: distances less than 300 km (53 firms), between 300 and 700 km (28), between 700 and 1300 km (23), and distances above 1300 km (9).

Figure 2: Distributions according to sub-groups variables



The partitioning with respect to the type of goods was made in the following way: food products in the first group (14 firms), minerals, materials, fertilizers, petroleum and agricultural products all together in the second group (17), steel products in the third group (10), chemical and pharmaceutical products in the fourth group (8). The last group is made of diverse products (64).

The data were also partitioned according to the willingness to switch mode (74 firms), and unwillingness (31). This information was lacking for eight firms.

Finally, the type of loading units provided another partitioning according to whether a simple truck of semi-trailer was used (97 firms), or a container (11), or the loading was made on a wagon or a barge (5).

In some cases the number of firms in a sub-group is rather small. This should affect the real level of significance of the utility functions' parameters when estimated over separate sub-groups, despite the high numbers of degree of freedom resulting from the data 'explosion'. Nevertheless, in a first research stage, separate estimations of the rank ordered model were made. They exhibited satisfactory likelihood ratio tests, Estrella statistics[3] varying between .15 and .79, and average Kendall's rank correlations[4] between .28 and .88. All the parameters had the correct sign, and most of them were highly significant, with the exception of the Frequency's coefficients and a few others in the rail and inland waterway sub-groups. Detailed results are presented and commented in Bouffioux et al. (2005). Regardless of the number of observations problem, such an analysis by sub-group interestingly highlighted the large spread of attributes' values among firms.

However, upon further examination of these results, it turned out that tests on equality of coefficients across data sets (Ben-Akiva et al., 1992) demonstrated that most of the sub-groups attributes' coefficients across a set of subgroups were not significantly different from each other. Only the Cost coefficients were found to be significantly different. Hence, in a second stage, we estimated for each set of subgroups a single utility function where Cost has a specific coefficient for each subgroup and all the other attributes' coefficients are common.

The results of these estimations are presented in Table 2. They can be compared to the results of the global estimation made without reference to sub-groups, results that are given at the top of the table. Like the global equation estimates, all the coefficients have a correct sign, i.e. negative for Time and Cost, but positive for the other attributes. Also, they are all very significant, and, of course, the likelihood ratio tests are all quite conclusive. Compared to the global estimation results, the Estrella statistics are slightly improved by the specification of a set of Cost variables. The Kendall's statistics are higher, but their relatively modest levels indicate again how heterogeneous the sample is. We observe that the successive sets of common coefficients are all very similar and close to the global estimates. In contrast, the Cost coefficients take substantially different values from one set to another. These differences imply that the relative weights of the quality attributes in decision making as well as their equivalent money values change from one sub-group to another.

[3] The Estrella statistic (1998) is similar to the better known statistics of McFaddden, but its definition makes it closer to an R^2. Although its domain of variation is between 0 and 1, it tends, like a R^2, to have low values in discrete choice models. On its meaning in this context, see J.S Cramer (1991, Ch. 5).

[4] Correlation between the observed and estimated rankings. Here, it is the average of its values obtained for each firm's ranking.

Table 2: Empirical results

Categories	Mean Kendall	Estrella	Parameter	Estimate	StdErr	tValue	ProbCh
Global	0,34	0,20	Frequ	0,194	0,046	4,21	<,0001
			Time	-0,016	0,003	-4,58	<,0001
			Reliab	0,037	0,002	14,85	<,0001
			Flex	0,016	0,002	7,41	<,0001
			Safety	0,033	0,003	11,59	<,0001
			Cost	-3,263	0,279	-11,68	<,0001
Goods value		0,214	Frequ	0,128	0,037	3,46	0,0005
			Time	-0,017	0,003	-4,76	<.0001
			Reliab	0,037	0,002	14,83	<.0001
			Flex	0,017	0,002	7,78	<.0001
			Safety	0,032	0,003	11,26	<.0001
1 : Low value	0,33		Cost-1	-6,858	0,838	-8,18	<.0001
2 : Middle value	0,37		Cost-2	-3,608	0,504	-7,15	<.0001
3 : High value	0,40		Cost-3	-1,976	0,322	-6,13	<.0001
Distance cat.		0,222	Frequ	0,127	0,037	3,43	0,0006
			Time	-0,017	0,004	-4,97	<.0001
			Reliab	0,037	0,002	14,69	<.0001
			Flex	0,017	0,002	7,49	<.0001
			Safety	0,033	0,003	11,50	<.0001
1 : <=300 Km	0,35		Cost-1	-3,482	0,392	-8,89	<.0001
2 : 300<D<=700	0,50		Cost-2	-1,797	0,344	-5,22	<.0001
3 : 700<D<=1300	0,72		Cost-3	-8,354	1,275	-6,55	<.0001
4 : >1300	0,46		Cost-4	-20,281	3,689	-5,50	<,0001
Mode		0,284	Frequ	0,127	0,037	3,41	0,0007
			Time	-0,019	0,004	-5,42	<,0001
			Reliab	0,038	0,003	15,29	<,0001
			Flex	0,018	0,002	7,94	<,0001
			Safety	0,033	0,003	11,50	<,0001
1 : Road	0,36		Cost-1	-2,965	0,269	-11,02	<,0001
2 : Rail	0,27		Cost-2	-107,907	13,819	-7,81	<,0001
3 : IN	0,37		Cost-3	-546,220	52,848	-10,34	<,0001
4 : Others	0,45		Cost-4	-9,736	1,924	-5,06	<,0001
If change		0,208	Frequ	0,125	0,037	3,37	0,0008
			Time	-0,017	0,003	-4,78	<,0001
			Reliab	0,037	0,002	14,71	<,0001
			Flex	0,017	0,002	7,61	<,0001
			Safety	0,033	0,003	11,34	<,0001
0 : missing	0,36		Cost-0	-7,246	1,124	-6,45	<,0001
1 : yes	0,37		Cost-1	-3,600	0,433	-8,32	<,0001
2 : no	0,31		Cost-2	-2,282	0,372	-6,14	<,0001
Goods cat.		0,248	Frequ	0,131	0,037	3,54	0,0004
			Time	-0,017	0,004	-4,81	<,0001
			Reliab	0,038	0,002	15,21	<,0001
			Flex	0,018	0,002	8,09	<,0001
			Safety	0,032	0,003	11,27	<,0001
1 : Foodstuffs	0,47		Cost-1	-16,274	2,118	-7,68	<,0001
2 : Minerals ...	0,27		Cost-2	-3,459	0,743	-4,66	<,0001
3 : Metal products	0,51		Cost-3	-74,338	9,521	-7,81	<,0001
4 : Chemicals-Pharma	0,40		Cost-4	-3,368	0,668	-5,04	<,0001
5 : Miscellaneous	0,33		Cost-5	-2,493	0,306	-8,14	<,0001
Loading unit		0,278	Frequ	0,131	0,037	3,51	0,0005
			Time	-0,019	0,004	-5,31	<,0001
			Reliab	0,038	0,003	15,19	<,0001
			Flex	0,017	0,002	7,69	<,0001
			Safety	0,034	0,003	11,80	<,0001
1 : Semi-trailer	0,35		Cost-1	-3,080	0,271	-11,36	<,0001
2 : Container	0,52		Cost-2	-88,571	9,166	-9,66	<,0001
3 : Others	0,70		Cost-3	-369,043	39,569	-9,33	<,0001

Table 3 gives the attributes' rela

tive weights in decision making. These weights are computed on the basis of the attributes' variation in a group of firms, as in the formula

$$w_j = \frac{|\beta_j|(x_j^* - x_{*j})}{\sum_{i=1}^{6} |\beta_i|(x_i^* - x_{*i})}$$

where x_j^* and x_{j*} are respectively the maximum and minimum value of an attribute *j,* and β_j is its estimated coefficient in the utility function. From the first line, which refers to the global estimation, it appears clearly that Cost is the dominant factor with a 63.7% weight. The next most important factor is transport Time with 16%. Reliability obtains a weight of 8.5%. Flexibility comes next in degree of importance (5.6%), followed by Frequency (3.36%) and Safety (3.15%).

Nevertheless, strong variations appear between sub-groups of firms. Sure enough, Cost remains the dominant decision factor with a weight of at least 46.1%, and most often with a much higher weight. Observe in particular that it is a very important factor for the firms that would be ready to switch mode, whereas those that would not consider any change give a reduced role to Cost and the highest importance to Time. In general, Time is given more importance than Reliability, but the inverse appears in a few important cases, like for short distance and road transports, as well as for transports of chemical and pharmaceutical products. Reliability does not play an important role for inland navigation and short-sea shippers, and for the transports of steel products.

Table 3: Weights

Variable		Frequ	Time	Reliab	Flex	Safety	Cost
Global		3,16%	15,92%	8,47%	5,63%	3,15%	63,67%
Goods value	Low	3,12%	11,42%	6,56%	5,95%	2,66%	70,30%
	Middle	2,97%	15,36%	8,06%	4,48%	2,91%	66,22%
	High	5,26%	11,49%	6,23%	6,30%	4,68%	66,05%
Distance cat.	<=300 Km	3,46%	3,77%	8,32%	6,34%	2,81%	75,30%
	300<D<=700	5,05%	19,88%	8,31%	5,70%	4,52%	56,54%
	700<D<=1300	2,05%	11,42%	5,90%	2,38%	2,20%	76,04%
	>1300	6,33%	12,24%	9,25%	4,70%	4,84%	62,63%
Mode	Road	3,77%	6,91%	9,53%	5,89%	3,85%	70,05%
	Rail	3,48%	22,45%	11,20%	4,58%	3,42%	54,87%
	IN	2,96%	14,66%	5,58%	7,19%	2,79%	66,81%
	Others	4,50%	14,25%	5,11%	5,93%	3,83%	66,38%
If change	missing	7,29%	4,05%	9,05%	8,77%	5,82%	65,02%
	yes	2,98%	11,45%	6,49%	5,80%	3,11%	70,16%
	no	4,73%	25,29%	13,10%	7,17%	3,57%	46,14%
Goods cat.	Foodstuffs	3,76%	4,00%	4,61%	3,06%	3,06%	81,51%
	Minerals ...	4,35%	22,87%	12,21%	8,58%	3,25%	48,73%
	Metal products	2,26%	3,50%	4,43%	2,32%	1,90%	85,58%
	Chemicals-Pharma	3,72%	3,88%	8,00%	3,82%	2,64%	77,92%
	Miscellaneous	4,32%	11,06%	10,43%	6,65%	4,16%	63,38%
Loading unit	Semi-trailer	3,25%	18,73%	8,98%	4,77%	3,30%	60,96%
	Containers	4,12%	9,72%	6,88%	4,66%	3,20%	71,42%
	Others	3,45%	4,14%	6,98%	8,77%	3,61%	73,06%

Another way to interpret the results is to compute the equivalent monetary values of each quality attribute. This is simply done by computing the ratio of a quality attribute's coefficient to the corresponding Cost's coefficient. These ratios assess how much a decision maker would be ready to pay for obtaining a better service quality, for instance a better Reliability. Inversely, they measure the cost for the firm of a lower quality level, i.e. the tariff reduction they could demand as compensation. These ratio values per tonne-km are given in the first five columns of Table 4. The next column gives the value of time for a transport of median distance in each sub-group. The last three columns characterize a transport by the median measures of distance, time and shipment size. In the light of the wide heterogeneity of situation and circumstances of the shipping firms, we judge that this information is most important for a good understanding of estimates.

Table 4 Quality attributes' monetary values per tonne-km

		Frequ (per day)	Reliab (per % point)	Flex (per % point)	Safety (per % point)	Time in €per hour per ton-km	Time in €per ton per hour for the median dis.	Median distance (Km)	Median time (hour)	Median shipment size (Ton)
Global		0,0394	0,0112	0,0051	0,0101	0,0050	1,5896	320	11	20
Goods value	Low	0,0187	0,0054	0,0025	0,0047	0,0024	0,7520	310	6	24
	Middle	0,0356	0,0102	0,0048	0,0090	0,0046	1,1656	253	19	13
	High	0,0650	0,0187	0,0088	0,0164	0,0084	5,4727	650	24	18
Distance cat.	<=300 Km	0,0365	0,0105	0,0048	0,0095	0,0050	0,6062	121	3	20
	300<D<=700	0,0707	0,0204	0,0093	0,0185	0,0097	4,2029	433	11	20
	700<D<=1300	0,0152	0,0044	0,0020	0,0040	0,0021	1,8796	900	48	20
	>1300	0,0063	0,0018	0,0008	0,0016	0,0009	1,1923	1386	48	15
Mode	Road	0,0427	0,0130	0,0060	0,0112	0,0066	1,8186	277	6	19
	Rail	0,0012	0,0004	0,0002	0,0003	0,0002	0,1788	991	48	28
	IN	0,0002	0,0001	0,0000	0,0001	0,0000	0,0054	151	48	725
	Others	0,0130	0,0039	0,0018	0,0034	0,0020	2,0296	1015	72	19
If change	missing	0,0172	0,0050	0,0023	0,0045	0,0023	0,4784	208	14	21
	yes	0,0346	0,0102	0,0047	0,0090	0,0046	1,5918	343	13	20
	no	0,0546	0,0160	0,0075	0,0143	0,0073	2,7818	380	11	19
Goods cat.	Foodstuffs	0,0081	0,0023	0,0011	0,0020	0,0010	0,1915	185	3	15
	Minerals ...	0,0380	0,0110	0,0052	0,0094	0,0049	0,5990	123	4	25
	Metal pr.	0,0018	0,0005	0,0002	0,0004	0,0002	0,1060	468	13	25
	Chemicals-Pharma	0,0390	0,0113	0,0054	0,0096	0,0050	1,4715	294	25	13
	Miscellaneous	0,0032	0,0009	0,0004	0,0008	0,0004	0,1839	443	24	19
Loading unit	Semi-trailer	0,0424	0,0124	0,0056	0,0111	0,0061	1,8359	301	8	20
	Container	0,0015	0,0004	0,0002	0,0004	0,0002	0,1861	876	24	24
	Others	0,0004	0,0001	0,0000	0,0001	0,0001	0,0204	400	48	1000

* Values for each qualitative attribute are ratios of the attribute's coefficient (Tableau 1) to the corresponding cost coefficient.

It is worth underlining that, in contrast with the weights of Table 3, the attributes' monetary values do not reflect in the same way the relative importance of each attribute in decision making, so that they cannot be simply compared one to one. Indeed, they refer to attributes defined in non-comparable units, so that the fact that the value of one hour is higher than the value of one percentage variation of Reliability does not mean that Time is a more important factor for the decision maker.

We observe in Table 5 that the quality attributes' value per tonne-km varies very much from on sub-group to another. The lowest values are found in the inland navigation sub-group, where they are close to zero. The values for the rail shippers are slightly higher. The highest values of Frequency are attributed by the shippers of more valuable goods and for transports over 300 to 700 km. This is also the case for the other quality attributes. In particular, the value of Time would reach a level of .0084 € per tonne-km for high valued goods over a median distance of 654 km; it would even reach the level of .0097 € for the group of distances between 300 and 700 km.

The value of Time has been the object of many different studies and estimates, so that we also computed it for a transport of median distance[5]. This only involves the multiplication of the Time/Cost ratio by the median distance, since the ratios in Table 5 are values per tonne-km. Computed from the coefficients of the global estimation, its value is about 2.4 € for a distance of 497 km. However, its estimates vary much from one to another group, with a minimum of .0054 € for a shipper using inland navigation over a distance of 151 km and a maximum of 5.4727 € for a shipper of valuable goods over a distance of 650 km.

In order to obtain the values per transport for the other attributes, similar multiplications can be done with the relevant ratios. Thus, shippers of containers over a median distance of 876 km, would be ready to pay 1.31 € for an additional service day (Frequency), .35 € for a one percent increase of Reliability, 4.91 € for a one percent increase in Flexibility, as much as 9.72 € for a one percent increase in Safety, and .18 € for a one hour gain in transport time (i.e. 2.16 € for half a day).

As mentioned in the introduction, it is rather difficult to compare results obtained with different methodologies and different samples reflecting different transport circumstances. This is all the more difficult because information about the samples is often not published in sufficient details. The reader may wish to consult the paper by de Jong (2000) as well as the report by de Jong et al. (2002) that review some estimates of the value of

[5] A median distance is more appropriate than an average distance in view of the dissymmetry of the samples.

time that are available in the literature. The following Table 5 provides another comparison with a few more recent results. In this table a column titled like 'Road or Rail' refers to a research focusing on the choice between these two modes. The results of the present study are given both for the average and the median distance.

As can be seen, that table exhibits a large spread of values, which should not surprise the reader in view of the results obtained in the present research. Actually, a somewhat more useful comparison could be made only if some information is given about the type of transport it relates to, i.e. the type and value of the goods, the logistic organization, the configuration of the transport network, etc. The following Table 6 provides information about the transport distance, the shipment tonnage, and the Transport time, which is available in the report by de Jong et al. (2002) and for the present research. The table shows some very different characteristics between the samples.

The road sample of the present study corresponds to heavier load transports over longer distances and taking more time. The value of time for the concerned Belgian shippers is lower per tonne than the value for the Dutch shippers in the report by de Jong et al.. In contrast the value of reliability is higher for the Belgian shippers.

The rail sample of the present research is characterized by longer distances and times, but the loads are smaller. Both the values of time and reliability are smaller than in the Dutch sample. A similar picture is presented by the comparison of the two inland navigation samples. It is not possible to derive any general rule from these observations.

Tableau 5: Comparison of results

Value of Time per hour in € per tonne for a typical transport

Authors	Road	Rail	Road or Rail	Inland navigation	Road or inland nav.
de Jong (€2002) *(m)*	4.74	.96		.046	
Fowkes et al. (€2002)*(d)*	.08-1.18	.08-1.21			
Kurri et al. (€2002) *(d)*	1.53	.09			
Danielis et al. (€2001)			3.05-3.55		
STRATEC (€1999)			.34-2.56		.11-.26
Bolis and Maggi (€1998)			.69		
Rudel and Maggi (€2004) *(m)*			046-1.98		
Blauwens and Van de Voorde (€2002) *(d)*				.09	
Beuthe and Bouffioux (€2003) *(m)*	1.82	.18		.005	
Beuthe and Bouffioux (for average distance)	2.88	.17		.009	

Note: *(d)* indicates values adjusted in €2002 by de Jong (2002). The numbers provided by Danielis et al. have been adjusted by the authors for comparison purpose. *(m)* indicates values computed with respect to median distance; other values likely are computed for an average distance.
Source: de Jong et al. (2002), Stratec (1999), Danielis (2002), Danielis et al. (2005), Rudel and Maggi (2005).

5. Concluding remarks

Our general conclusion is that the relative importance and the value that a transport manager may give to the service quality attributes of various transport solutions depend on many different factors: the type and the value of goods, the distance and time of transport, the internal and external logistics of the firms, and the configuration of the network. The large spread of results over the different partitions of our sample bears witness to that heterogeneity of attitudes and situations.

The comparison with other published studies also showed a large dispersion of results. Part of that dispersion may be explained by methodological differences in techniques of survey and in statistical analysis. However, it is likely that much of that dispersion can be attributed to differences in samples. The fact is that the samples are often rather small, because of the difficulty and cost of obtaining interviews from transport managers. Hence, the samples in different studies are only sub-samples gathering observations on firms and transport managers confronted with very different transport situations and requirements.

This general observation implies that the economic analyst should be cautious when considering the inclusion of estimated values of time, reliability and other qualitative factors in traffic analyses. Rather than using average values, on could wish to consider distributions of values, in ways similar to what is done in people transports analyses. However, this is quite a challenge in terms of sample size, which has not yet been met. To some extent, average values per type and value of goods, or per distances bracket, as computed in this research, could solve part of this problem.

Whatever may be done about this basic research problem, our own effort has shown that the qualitative attributes of transports play an very important role in the choice of a transport solution. Even though transport cost clearly appears the dominant factor in all cases, quality attributes taken all together weigh 36 % in average on the shippers' decision. Hence, their consideration should be integrated in any freight transport policy.

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