SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

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ASSESSMENT OF QUALITY DIFFERENCES BETWEEN FREIGHT TRANSPORT MODES
CP-36

FUCAM – UCL – UFSIA - RUG

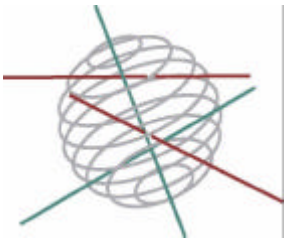
SPSD II

PART 1
SUSTAINABLE PRODUCTION AND CONSUMPTION PATTERNS

GENERAL ISSUES
AGRO-FOOD
ENERGY
TRANSPORT

This research project is realised within the framework of the Scientific support plan for a sustainable developmentpolicy (SPSD II)

Part I "Sustainable production and consumption patterns"



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SSTC

Assessment of quality differences between freight transport modes
The first annual scientific report

CP-TR-03 of PADD II

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1. Introduction

1.1. Context and summary

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. Indeed, over the last two decades, transport management and organisation have been progressively integrated into the management of the complete logistic chain from the production of goods to their commercialisation (Blauwens et. al., 2002). In this context, it is not anymore sufficient to analyse the monetary costs and time of transports. Service qualitative attributes must also be taken into account for developing an appropriate modal shift strategy.

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 modes.

1.2. Objectives

The usual statistical approach on published data is 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 must of necessity start with and rely on a survey of transport decision makers. This survey should cover all relevant factors: 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). Such a survey will then provide a relevant data basis for an appropriate econometric analysis of modal choices.

Given the time framework of the research program and the complexity of the problem, this survey must be seen as a pilot-survey among Belgian enterprises. Nevertheless, the international character of Belgian economic transport activities will provide a relevant domain of enquiry. At this stage, the modes that will be the main objects of the survey are the road,

the rail, the waterways, and their multimodal combinations. Short-sea-shipping will not be excluded, but will not be among our priorities. We hope this pilot-survey will provide a good basis for a more extensive research at a larger international scale, and including fully air transport and short-sea shipping.

1.3. Expected outcomes

In the limited time scope of this research, our consortium aims at developing a good critical knowledge of the field of revealed and stated preference methodology through an extensive review of the relevant literature in the freight transport field, but also in other fields where this methodology has been more intensively applied: in passengers transport analyses, in marketing and in econometrics. This task is essentially completed, but will be perfected as the research progresses. Our understanding of the issues involved has been supplemented by a set of in-depth interviews of decision makers in the field.

On the basis of this understanding, we have already developed and tested a survey questionnaire that will now be applied to more Belgian shippers in various industries. Because it is a pilot-survey, taken as a learning approach, it will be applied by the members of the consortium in face-to-face paper interviews that will provide a lot of additional information on decision making in this field. That should help us to better interpret the data of the survey. The sample of shippers will be as large as possible given the man-power resources of the consortium and the logistics of organising interviews with willing decision makers. For the same reason, it will not be a random sample but a representative sample of key industries concerned with a modal choice.

The data will be analysed with several econometric models, in order to identify the most appropriate model specification and to reach appropriate statistical analysis recommendations. In this research, the emphasis will be placed on elements that could be added to existing transport models, like money equivalent value of qualitative attributes, and that would be useful for developing a strategic policy of modal shift.

The research will be supplemented with a few in-depth case studies. Finally, its conclusions will propose a framework for a larger scale survey focusing on the main factors identified through the pilot survey.

2. The methodology

As explained above, the survey methodology and the questionnaire development are based on an extensive review of the literature, some in-depth interviews, and several pre-tests. A summary of the information gathered in this way will appear in Section 3 of this report. Likewise, the review made of possible econometric models will constitute the basis of the subsequent analysis of the data provided by the survey. At this stage of our research, the questionnaire that will be addressed to Belgian shippers constitutes the main well defined element of our methodology. It is the outcome of lengthy iterative discussions, in which all the consortium members contributed. 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. This section 2, mainly presents and comments this questionnaire.

The target population of the survey is all the shippers of freight in all industries to destinations in Europe. The modes included 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 parts of Luxembourg. As we are focusing on possible modal shifts, we exclude urban and distribution sector's activities on short distances. There is a reduced opportunity over short distances for non-road transports, but no minimum transport distance is set for the survey, since, actually, there are cases of industrial goods transported over short distances by rail or by inland navigation.

The sampling frame from which the interviews will be drawn is the list of all Belgian firms which have at least 20 employees. Given that this is a pilot survey, we have not chosen to proceed through random sampling, but opted for a representative quota sampling. The tonnage of each category of commodity in the sample should be in proportion to the NST-R shipment categories; the tonnages should also be in proportion to the shipments by each mode, and shipments from the different provinces should be in proportion to their economic activities. The final sample size will depend on the cooperation we will obtain from the shipping firms over the next six months.

The questionnaire[1] is made of two parts. In part A, the first questions (A.1) relate to the general characteristics of the firm and, more specifically, the characteristics of the particular plant from which some shipping flows originate. A second set of questions (A.2)

[1] The full questionnaires can be found in references 10 and 11. Additional comments on the questions and their motivation can be found in a working note (reference 4).

focuses on the plant transport organisation. Thus, most of the characteristics of a large firm management centre or other plants are not included in this questionnaire. Part B starts with the definition of a typical transport flow (B.1) on which the stated preference experiment will focus. The experiment itself (B.2) is based on an orthogonal set of 25 transport alternatives. It is followed by an additional set of questions (B.3), asking whether the availability of some preferred alternatives would lead to a modal shift, or under which conditions a modal shift would be accepted.

Given the option of a face-to-face interview, which permits to give additional explanations to the interviewee, we have chosen to present full profile transport alternatives. This option is particularly recommended when the purpose is to identify the relative importance of qualitative attributes for hypothetical new transport solutions. Also, we choose to ask the respondent to rank a set of transport alternatives. In this rather complex context, this methodology appeared the most reliable.

Two identical versions of the questionnaire were written, one in Dutch, the other one in French, since the survey will be addressed to both Dutch and French speaking decision makers.

A.1 The characteristics of the shipping plant

- Question 1 concerns the coordinates of the plant, its NACE-BEL code, plus the size of the firm measured by its turnover and labour force. Many of these items can be filled in before the interview.
- Question 2 asks to specify the plant's type of operation (production, wholesale merchant, logistic centre, etc.).
- Question 3 focuses on the identification of the decision making actor as far as transport is concerned: the central management of the firm, the shipping plant, a forwarder, etc. The question is raised at three levels: the definition of strategic options, the decision on its characteristics, and its execution.
- Question 4 bears upon the possible choice of outsourcing and the decision criteria taken into account in that respect. A number of standard criteria are suggested but some others may be proposed.
    - Out of pocket cost paid for transport;
    - Reliability of delivery according to scheduled time
    - Door-to-door transport time including loading and unloading;

- Frequency of service proposed by the carrier or forwarder;
- Tracking and tracing service;
- Flexibility of supplied service;
- Losses resulting from transport;
- Others to be specified.

- Question 5 asks whether the firm uses its own vehicles' fleet and loading units (containers, boxes, semi-trailers, etc.). It supplements the information obtained through the previous question.
- Question 6 is about the accessibility to the networks of waterways, railways, superhighways and harbours. Direct accessibility at the plant site and indirect accessibility in km are distinguished. Accessibility may be an important factor in the short run transport choice. Information from question 6, and from questions 11 and 14, could be useful for setting up an accessibility function as suggested in the literature.

A.2 The transport organisation

- Question 7 asks the level of transport budget, and its percentage of production costs as an indicator of the relative importance of the transport cost factor.
- Question 8 asks the percentages of turnover according to the destination countries and according to distance categories. These categories are set according to the maximum distance that a trucker is allowed to travel during a working day.
- Question 9 asks the percentages of the annual tonnage shipped by the different transport modes or combination of modes.
- Question 10 asks the average commercial value per kg of the shipped goods, as an indicator of the in-transit inventory cost. The cost categories are set according to a segmentation analysis of value/weight ratios for different type of goods.
- Question 11 concerns the different categories of goods transported, bulk or containerised, dangerous or not, dry or fluid, reefer or not.
- Question 12 asks the annual tonnage of the above categories per mode of transport, and a shipment's average size in appropriate units (TEU, pallets, barrels, tonnes, etc.).

B.1 The typical transport flow

- Question 13 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, and the type of consignee. The case corresponding to this typical flow will form the basis of the stated preference experiment.

- Question 14 is, like questions 11 and 12, on the type of transport category and mode (or combination of modes) chosen; it also asks whether there are specific circumstances about that flow that may condition its organisation (network access, loading / unloading equipment, goods fragility, etc.), how transport is managed, and under which contractual conditions.
- Question 15 asks the level of each attribute for this typical flow. This concrete information is essential for an analytical interpretation of the preference ranking provided by the stated preference experiment. On the basis of the literature as well as some in-depth shippers' interviews, and considering an acceptable level of complexity of the interview task, six attributes are selected for defining the transport alternatives submitted to the shipper. These attributes 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 proposed 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.

  Some of the criteria are defined in % of occurrences in order to encompass the idea of probability or risk affecting these criteria. In the same question, it is also asked to indicate whether some other relevant factors are taken into account.
- Question 16 asks to give a weight of relative importance to all those factors as far as this specific flow is concerned.
- Question 17 asks whether the interviewed decision maker would consider a modal switch in the future for some flows shipped from the plant. Questions 16 and 17 already prepare the interviewee to the stated preference ranking experiment.

Much of the information provided by sections A.1 to B.1 of the questionnaire could be used in various econometric analyses.

B.2 The stated preference experiment

This experiment is based on an orthogonal design of 25 transport alternatives defined by various levels of the six main attributes (Addelman, 1962). Thus, it will focus on the main effects of attributes, and set aside their interactions. Given available statistical evidence and the main forecasting purpose of our research, this restriction seems appropriate. The attributes are defined as above, but their levels are given in percentages of variations with respect to the status quo transport solution (alternative 1), which is included among the 25 alternatives. This specification allows the use of the same set of alternatives in all interviews[2]. Moreover, it clearly defines the appropriate reference situation from which a potential modal switch should be envisaged (Department for Transport, 2002, Ch.12). Table 1 enumerates some of the 25 alternatives. Alternative 15 percentage variations from status quo clearly define it as a better solution than the status quo, since all its attributes' levels are preferable, whereas alternative 17 is clearly an inferior solution. These two alternatives plus the status quo provide a frame of reference to the respondent for assessing all the others.

Table 1: Examples of stated preference 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 status quo may very well have an attribute with value close or equal to 100% (or 0%). This would constraint a positive % variation (or negative one). Such a situation should be indicated to the decision maker who should take it into account in his / her preference ranking.

The interviewed decision maker must simply rank the alternatives according to his/her preference considering their attributes' levels. Each alternative is presented separately on a card, so that the interviewee is able to proceed stepwise dividing the set of cards into sub-groups of different preferences, and ordering the cards next to each other.

It is noted that none of the alternatives, except the status quo, is characterised by a specific mode use. Actually, they may not necessarily refer to the same mode as the status quo one, since they are hypothetical alternatives. This wider framework of reference will be emphasized to the interviewee.

B.3 The modal shift analysis

As explained above, the stated preference experiment does not explicitly introduce any mode choice; it just provides an order of preference among alternatives without any reference to a mode (except for the status quo). It is likely that some alternatives will be preferred to the status quo solution. We can presume that a preferred solution would be chosen if it was available without a modal switch, but we cannot necessarily infer from the preference order that a modal shift, if needed, would be accepted. In order to find out whether some alternatives preferred to the status quo would be chosen even though they would involve a modal shift, some additional questions are needed.

- Question 18 asks whether the decision maker would be ready to switch mode in order to benefit from some of the preferred alternatives.
- In case of a positive answer, question 19 asks towards which mode there would be a switch for each of the preferred alternatives.
- Question 20 asks whether the switch would involve an investment in equipment or (relatively small) infrastructure and the amount to be invested.
- In case of a negative answer to question 18, question 21 asks whether it is because of the involved investment (and its amount), or for another reason.
- In the same negative case, question 22 asks to indicate the variations of the attributes levels that would be required in order to bring about a modal shift.
- In case the flow's total tonnage would not be switched to another mode, question 23 asks which percentage would be switched. This information will be useful for computing transport demand elasticity.
- Finally, question 24 asks again to rank the relative importance of the different criteria. It is aimed at checking whether the ranking was actually done according to the relative importance indicated in question 16.

Stated preference estimates of attributes' weights or valuations will be obtained from the B.2 part. Some other estimates will be derived from the additional questions in B.3 on mode choice for the preferred alternatives. These estimates could be of different values and will be compared, since there is some statistical evidence that estimates derived from a modal split analysis may differ from those derived from a single mode analysis.

However careful has been the preparation of the questionnaire, some specific features of shipping firms will not come through the answers. Given that the interviews will be face-to-face with the possibility of helping the decision maker in its understanding but also of listening to his/her oral comments, some additional information undoubtedly will be gathered. Likewise, the interviewer observation of preference ranking will provide 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. A short interview guide will be written calling the interviewer's attention to a few important points to watch.

The specific econometric models that will be used to analyse the data remain to be defined. The working papers summarized in Section 3 contain a number of suggestions. Revealed preference data will lead to classic discrete choice models, whereas the stated preference data will be better analysed by ordered probit and logit models. Models combining the two types of data also will be considered. Hybrid models combining individual and grouped data could also be tested (Green, 1996). All these models will allow the derivation of money equivalent values that could be introduced in other transport models. If time allows, an application of neural network methodology is envisaged as an alternative statistical methodology.

Multicriteria analysis along the line of the UTA model, which derives piecewise linear additive utility functions from ranking data, could also be a useful tool, particularly for analysing individual data. An example of its use is given in the next section.

3. Intermediary results

3.1 Preliminary tests interviews

Before setting the questionnaire in its final version, a very similar version was experimented during the month of October with eight decision makers from the steel and chemical industry, a food factory, the building materials sector, and a soft drink factory.

The comments received indicated that the questionnaire was globally adequate and feasible. Only a few clarifications were needed, which have been implemented already.

The time taken to apply the questionnaire, including an open discussion of related issues, never took more than two hours. For the larger scale survey, the questionnaire will be sent beforehand after a first telephone call to set an interview date. This should allow a shorter interview time (normally) not exceeding one hour and a half.

The number of interviews was too small to attempt any econometric analysis. However, an application of the multicriteria UTA model to individual ranking data was possible. Its use can be illustrated here with the case of a steel making plant using a multimodal solution (barge, rail, truck) for transporting coils towards Italy over a distance of 991 km. The decision maker's ranking was used as an input in the UTA software MUSTARD (Scannella and Beuthe, 2001).

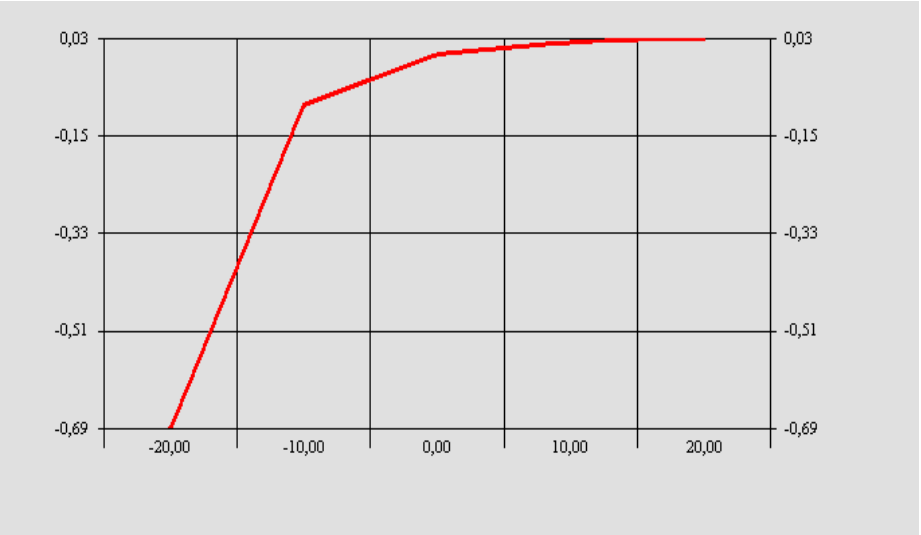
The estimated weights of the additive decision function were: 0.007 for Frequency, 0.029 for Time, 0.114 for Reliability, 0.042 for Flexibility, 0.084 for Loss and 0.724 for Cost. Five alternatives were deemed preferable to the status quo solution, and the decision maker expressed the intention of switching mode if they would be made available.

On the basis of these results, it is also possible to compute the equivalent money value of an alternative or an attribute. For each day increase over the present transport time of 10 days, this shipper would be willing to accept a compensation of 2 EURO per tonne for the trip. For each percent decrease of reliability, the compensation should amount to 1.7 EURO per tonne. Since the UTA functions are piecewise linear, different lower values are estimated for the willingness to pay for an improvement: .07 EURO for each day less of transport time, and .08 EURO for each percent increase of reliability.

The following Figure 2 illustrates the partial 'utility' function estimated by MUSTARD for the COST attribute[3]. The utility decreases fast when cost increases above the status quo level, whereas it hardly increases when cost decreases from that level. Hence, an increase of cost is hardly acceptable for this decision maker.

Figure 2 : Example of partial 'utility' function for COST

[3] The abscissa is set in negative % of increase in order that its value correspond to a positive effect, whereas utility is scaled with respect to a zero utility at the status quo point (0% of variation).



3.2 Review of the literature

3.2.1 Review of the passenger transport literature on quality attributes

The report by F. Witlox and B. Van Broeckhoven concentrates on the passengers transport literature. The role of quality attributes in people travel decision making has been extensively researched, so that this literature provides an obvious source of information and analytical tools for our research.

There are important similarities between the two fields. To the characteristics of the travelling people, their household and purposes of trip correspond the characteristics of the shippers, consignees and transported goods. The specific characteristics and circumstances are different, but their role in decision making is very similar. Moreover, the main factors taken into account are about the same: cost, time, frequency and flexibility of supplied service, reliability and safety. The comfort factor must be added for passengers, but some goods need to be handled with particular care or speed. Various factors of smaller importance ('others') doubtless have to be mentioned on both sides, as well as tracking and tracing for freight transport.

In both cases the decision process can be seen as a four-stage problem: trip generation, trip distribution, modal split and route assignment. For freight transportation, the four stages can be adjusted to determine successively (i) incoming and outgoing freight traffic per zone, (ii) the distribution of this freight traffic, (iii) the share of the various modes in these flows, and (iv) their assignment to the available infrastructure.

The main theoretical paradigm for modal choice is the discrete choice theory of a rational individual (McFadden, 1974), who is supposed to choose the alternative that maximises his / her utility. However, many factors make that utility uncertain: from the point of view of the traveller, incomplete information and the random character of the service, and, from the point of view of the statistician, the personal characteristics of the traveller and its subjectivity, plus the measurement and specification errors. On that basis, the conceptual model of decision making can be set in four stages: the choice set definition, the attributes' definition and evaluation, the utility of alternatives, the final choice. The two first steps are the main focus of the report.

Concerning the choice set, the main problem consists in determining which transport modes are available. This preliminary step may have an important influence on the modelling. Several solutions are proposed in the literature (see, for instance, Cascetta, 2001, and Louviere et al., 2000). The implicit approach includes availability/perception explanatory variables, like car ownership, frequency or access time for passengers, and infrastructure availability for freight. The explicit approach is much less used until now. It may be implemented by a priori restrictions (captivity parameters) imposed on the choice set, or by the modelling of a captivity (or accessibility) function based on the characteristics of the decision maker and attributes of the modes. Analysing choice set may be difficult in case the choice set is large. As it is rather limited for freight transport, this approach could possibly offer an interesting modelling alternative.

The report carefully reviews the various quality attributes' definitions that can be found in the passenger literature. It points out that different equivalent money values can be obtained for attributes according to whether a modal split or a single mode model is applied. One must also distinguish willingness to pay and willingness to accept in the modelling.

3.2.2 Review of the freight transport literature on quality attributes

The report by J. De Mayer and T. Pauwels is made of two parts. The first one is an overview of the existing demand models, their data and methods, the second one is concerned with the identification and valuation of quality attributes.

It starts by contrasting aggregate and disaggregate data. If available at the individual company level, the latter provide detailed information and greater accuracy in estimation. Nevertheless, they may be difficult to use for forecasting at the market level or for policy supporting predictions. Next, it compares revealed and stated preference disaggregated

data. Whereas revealed preferences data correspond to true observations of actual behaviour, they do not convey much information about choices that would be made in hypothetical circumstances. Also, such data may not be complete or numerous enough. It follows that most of the research made on quality attributes is based on stated preferences techniques.

The report gives a full explanation of the volume demand models, and particularly of the translog demand model which derives short run demand functions from a cost function. Then, it tackles the discrete choice models that already have been mentioned in the previous report. It shows how probability of choices can be derived in the multinomial logit model with aggregate and disaggregate data. The nested logit model also is explained. Finally, an introduction to the neural network model is given, and a few empirical analyses commented. It appears that a neural network analysis can provide useful information about the desirable specification of the model and its parameters, but that it does not outrank the usual classic econometric analyses.

In its second part, the report reviews the specific studies on quality attributes in freight transport, among them all those included in Danielis (2002). The attributes that appear as important are essentially the same in most studies, even though they may be affected by different weights: cost, time, frequency, reliability, losses, and flexibility. The way to compute their money equivalent through the logit model is explained.

3.2.3 Review of the marketing literature on stated preference techniques

The report by Christophe Bouffioux is mostly centred on papers from the marketing literature, a field in which stated preference techniques are often used under the name of conjoint analysis. Three interdependent topics are dealt with: the construction of efficient factorial design, the data collection and the corresponding models.

a) From the efficiency point of view, the report shows that, in the classic multinomial approach, the matrix of variance-covariance of estimators is a function of the choice probabilities, i.e. a function of the model parameters. Next, it reminds that minimisation of the model errors through minimisation of the geometric mean of variances and co-variances implies:

- orthogonality of the design, i.e. a frequency of joint occurrence of different attributes levels equal to the product of their marginal frequencies,
- level balance, i.e. equal frequency of each attribute level,
- minimum overlap of alternatives in successive choice sets,

- utility balance, i.e. equal utility (indifference) of alternatives in a choice set.

Unhappily, these conditions cannot be satisfied together in all circumstances. Considering the condition of utility balance, some authors, like Zwerina et al. (1996), have suggested that prior knowledge on parameters could be used to design alternatives with equal utilities. Some algorithms try to reach such a goal by composing successive alternatives that tend to be of equal utility on the basis of previous choices. Nevertheless, such a procedure can work against the two above frequency conditions.

There is also the problem of handling direct main effects versus effects from interactions between attributes. If neglected, important interactions may bias main effects estimates. This may be of less importance though for forecasting a total effect, and the advantage of a more detailed analysis may be counter-balanced by a loss in predictive performance. An orthogonal design does not allow correlated data and assumes that there are no interactions. To be realistic, the task of the respondent must remain manageable in length and complexity. Experiences from previous studies provide useful guidelines.

b) Several types of data collection are currently used in conjoint analysis. At one extreme there is the full profile technique whereby each alternative is described by the level of all attributes. The respondent is then asked to rank these alternatives according to his/her preference. A variant is to submit successive small set of full profile alternatives among which the respondent must choose, like in the methodology applied by STRATEC (1999). The respondent may also be asked to rate these alternatives on a given scale. At the other extreme, there is the compositional technique whereby the respondent first indicates on a scale the desirability of each level of an attribute, then give the relative importance of each attribute. Each alternative is then rated according to the weighted sum of its attributes levels. There is a number of hybrid techniques mixing these two types, like combining information given separately about each attribute and choices or preferences between full profiles or partial profiles.

Each approach has specific advantages. The compositional technique is useful when there are many attributes and in cases where the goal is not to analyse unusual alternatives. Full profile approach is recommended if the goal is to assess the impact of hypothetical alternatives with a limited number of attributes. Indeed, a large number of attributes could induce the decision maker to simplify the task, for instance, by discarding alternatives with the lowest attribute levels.

A choice also must be made between rating alternatives, ranking them or choosing an alternative in a subset. Rating alternatives potentially provides a more substantial

information to the extent that it gives a measure of preference intensity, but its reliability may be argued. In principle, it leads the respondent to think explicitly in terms of his/her 'utility' function[4]. Ranking alternatives certainly is an easier task, but it does not provide direct information on utilities. Choosing an alternative is the more realistic approach that may also provide a ranking. However, its convenience may lead to a lesser reliability and a less accurate weighting of the various attributes.

c) Various preference models can be applied. Choice data can be readily introduced in classic discrete choice models, whereas ranking data can be analysed with ordered logit or probit models. If the number of observations is sufficient, the statistical analysis can be made at the level of an individual respondent. The introduction of additional variables like the size of a firm, its localisation, etc. necessarily leads to an aggregate analysis of a sample of respondents. Note that some multicriteria analysis models can also be used to analyse these data.

Rating data can be used in two different ways. First, the alternatives' utility levels can be transformed into levels of choice probability and introduced as such in a discrete choice analysis. Second, ratings obtained from a compositional approach can be combined with results of a full profile analysis in a hybrid model. Then, in a regression analysis, the rating becomes an explanatory variable of the score levels obtained from a full profile questioning. This modelling allows to distinguish individual and group level parameters. Many variants of this hybrid approach can be developed (Green, 1996).

The available statistical evidence tends to show that the full profile methods out-perform the other methods, but it is not clear that this is always the case.

3.2.4 Statistical tools

A) Discrete choice models and the revealed and stated preference methodology

This report by M.Vandresse reviews the general issues confronted by revealed and stated preference approaches in the framework of the random utility discrete choice models. It starts by contrasting the two approaches. Real choices are revealed by observation, but they do not provide information about choices of new alternative solutions, whereas, preferences stated about hypothetical alternatives fill that gap, even though they indicate only intentions and not firm commitments. Concerning the data, revealed choices data may be incomplete and characterised by strong correlation among

[4] The terminology of 'utility' is not entirely appropriate in the context of freight transport, where the decision maker tends to maximize profit or minimize cost rather than to maximize utility. Actually, the terminology of "value" or "decision" function would be more appropriate, but is rarely used in this context.

explanatory variables, whereas stated choices data may be designed to satisfy desirable conditions of statistical analysis. Nevertheless, both approaches meet the same challenges of choices made in heterogeneous circumstances, and of imperfect information.

Next, the report compares the three different type of data that can be obtained from a stated preference experiment: simple choice data, ranking of a set of alternatives and rating of alternatives, and discusses the possible experimental designs. If the analysis is aiming at main effects rather than at interactions between attributes, a fractional factorial design with a limited orthogonal data matrix appears as a reasonable compromise.

The bulk of the report reviews the existing econometric literature on discrete choice. The well-known random utility model is presented with some emphasis placed on its handling of all random effects: the unobservable factors, the measurement errors, the specification errors. The stated preference design does not necessarily alleviate the two first types of error. Furthermore, the experimental process is not immune to imperfect answers by the respondent.

Next, a systematic review is made of the main econometric models:
The multinomial logit model (MLM), the multinomial probit (MPM), the nested logit model, the heteroscedastic extreme value model (HEV), the Mixed Multinomial Probit model (MMNP), a generalisation of the MLM and MPM to ranking data, the methodology for combining stated and revealed preference data. The handling of rating data is still to be reviewed.

The report concludes with several modelling proposals. Among others, two hybrid models are suggested where a deduced stated preference utility is used as an explanatory variable of a revealed preference utility or score.

B) The artificial neural network applied to the discrete modal choice

The report by G. Santamaria aims at examining whether it would be advisable to use this more recent approach from artificial intelligence research rather than the classic discrete choice models, and whether their comparison would be useful in the present context. It is still a research in progress.

At this stage it provides a clear definition of unusual concepts like neurons as information processing units, and discusses the techniques of optimisation that are used for estimation. A neuron computes a weighted sum of inputs that is used as argument of an 'activation' function, for instance a sigmoid function. The latter transforms the weighted sum into an output with value, for instance, between 0 and 1, which can be used to compute the probability of a mode choice. The weights result from an iterative

minimisation of the output error computed with respect to a threshold value. A neural network is composed of several such neurons.

In order to handle complex problems, it may be necessary to consider networks with several layers, where the output of one layer "feeds forward" the next layer as an input, and the last layer output is used as an input to the first layer in a "back propagation" iterative process.

Future work will compare the logit and neural approaches, which share some common elements like the use of a sigmoïd function, and will set up an application to the data of the stated preference experiment that is proposed.

3.2.5 Case studies

Despite the rather detailed character of the questionnaire, the data and their statistical exploitation will deliver only an outsider view of the firms' transport problem in some respects. It will not be able to go deep into the organisation of transport seen from inside the firm, including the management of information flows, stocks and just-in-time services to the clients. In particular, it will be unable to encompass all the practical aspects that abound in the running of efficient terminals and logistic platforms and the organisation of intermodal or multimodal transport. A few in-depth case studies should provide useful additional information for a better understanding of the whole issue of modal choice. Furthermore, in the context of the development of a sustainable mobility that public authorities want to promote, it seems appropriate to examine the impacts of policy measures implemented at different levels (European, Federal and Regional) in the context of some firms decision making.

As explained in the report by Van Broeckhoven, this work is already started on the basis of the first in-depth interviews. It will proceed forward with firms that surround and use the Willebroeck tri-modal container terminal. Another interesting case could be centred on the Meerhout terminal on the Albert canal.

Following Porter's (1980) conceptual model, the approach will be global, trying to analyse all the competitive forces that determine the inter-modal freight market: the suppliers of terminal facilities, the carriers and intermediaries, the shippers, the other terminals, and the direct transport services.

4. Prospects and planning

From January until July, we shall systematically apply the questionnaire to transport decision makers in all industries spread throughout Belgium. The search for interviews will be based on the list of all Belgian firms with at least 20 employees. In other to draw a representative sample, the sample will be stratified in proportion to the tonnages shipped of the different commodities (NST-R categories) and by the different modes. The geographical spread of firms will be in proportion to the Provinces' economic activity. The research assistants of the four universities will be involved in this task. The sample size of this pilot survey will depend upon the cooperation given by the firms.

In the meantime, the econometric models, estimation tools and data bank set-up will be prepared, so that the full data analysis could start without delay during the month of August. Obviously, some experiments on partial data will be performed as soon as possible. Individual data analysis will proceed along the interviews. Hopefully, the data gathered by this pilot survey will provide useful, if provisional, insights into transport modal choices.

The work on case studies by the University of Gent will continue during the full year. To some extent, it will use the input of all the free observations made during the interviews.

By the end of May, the experience accumulated during interviews, as well as the modelling work, will allow us to design an appropriate procedure for a larger scale survey.

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5. List of working notes and annexed reports

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2. Beuthe M., *Computation of money equivalent value with UTA*, Working note FUCAM, November 02.
3. Bouffioux Ch., J. De Mayer and B. Van Broeckhoven, *Justifications for the questions used in the questionnaire*, Working note GTM, September 02.
4. Bouffioux Ch., *Conjoint analysis of stated preference in the marketing literature*, Report GTM, December 02 (Annex 5.5)
5. De Mayer J., *Segmentation of goods*, Working note U.A., April 02.
6. De Mayer J and T. Pauwels, *Literature Review: quality of servicefor mode choice modelling for freight*, Report U.A., November 02 (Annex 5.4).
7. 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 03 (Annex 5.1).
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9. Santamaria G., *The artificial neural network in the discrete modal choice*, Report U.C.L, January 03 (Annex 5.7).
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