

# Analysing freight transport demand using stated preference data: a survey

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*The paper surveys the application of the stated preference technique to analyse freight transport demand. The objective is to identify what is contribution of the hypothetical data analysis to the understanding of freight transport markets, as opposed to the results obtained by using observed, revealed preference data.*

\* The paper is the result of a joint effort, though R. Danielis wrote section 1, 2 and 3, and L. Rotaris section 4.

## 1. Introduction\*

The objective of this paper is to evaluate the state of the art in the application of stated preference techniques to analyse freight transport demand. Stated preference (SP, hereafter) techniques can be characterised as a "family of techniques which use individual respondents' statements about their preferences in a set of transport options to estimate utility functions. The options are typically descriptions of transport situations or contexts constructed by the researcher" (Kroes and Sheldon, 1988). While there exist recent overviews of application of stated preference methods to passenger transport demand analysis (Hensher, 1994; Polak and Jones, 1997), a review does not exist, to the best of our knowledge, for freight transport. It is recognised that studying freight transport demand poses specific difficulties not faced in passenger transport analysis (Bolis and Maggi, 1998) since:

- freight is heterogeneous;
- modal choice is influenced by the physical characteristics of the goods to be moved;
- freight transport is a derived demand since it is a part of a larger industrial/logistic process;
- more than one decision maker (shipper, freight forwarder, carrier(s), receiver) is usually involved in the decision making process, no one of which has all information and decision power;
- geographic factors (presence of a port or a logistic node) influence transport choices;
- prices are part of a (often long term) contract, shippers are not price takers, and there is little information on prevailing prices.

Given the specific nature of freight transport markets, the paper aims at clarifying what is the contribution which SP-based studies could or did make to the understanding of freight transport demand. Particularly, we want to assess what SP studies could tell us about freight transport demand that could not be captured by traditional revealed preference-based studies (RP, hereafter). Finally, we discuss what issues remained unsolved and what might be the future of SP studies of freight transport demand. The paper is organised as follows. Section 2 recalls the main freight transport models to identify to which modelling framework SP data could be of use. Section 3 compares the

pros and cons of SP versus RP data. Section 4 illustrates some SP studies identifying the issues studied, the techniques applied and the results obtained. Section 5 presents a discussion and conclusion.

## 2. Modelling freight transport demand

Freight transport demand modelling has a long history. Mazzarino (1997), in a recent survey of the literature, identifies two main groups of models: macroeconomic and microeconomic models.

Similarly, Winston (1983) subdivides freight transport demand models into aggregate or disaggregate models. The most simple

aggregate model is the modal split model where the ratio between the market share of two modes is assumed to depend on differences in prices and in non price attributes (e.g., Boyer, 1977).

A more theoretically-grounded aggregate model is the neoclassical model (e.g., Friedlaender and Spady, 1980) which assumes that a firm is a neoclassical factor price-taking cost minimizer. The firm's demand for transportation by a particular mode results as a derived demand from the cost function, by using the Shepard's lemma. Assuming all firms in a region have the same technology and making use of transport flows data in that region, one can estimate the aggregate freight demand function for that area. In such a demand equation, the market share of one mode typically depends on transport and non-transport prices, the modal attributes and the level of output.

Disaggregate models have the theoretical advantage of being more firmly based on theories of behaviour and to allow for a richer empirical specification. The importance of variables such as shipment size and value can be tested whereas in aggregate models they are obscured in the aggregation process. Obviously, data requirements are more cumbersome since one must collect data on the characteristics of all modes (chosen and unchosen). Two types of disaggregate models have been developed in the literature: behavioural and inventory. A model is termed a behavioural model when it focuses on the mode decisions made by the physical distribution manager of the receiving or shipping firm (Winston, 1981). It is termed an inventory model whenever it comprises also the decisions of the inventory manager, including logistic and production decisions (Baumol and Vinod, 1970; McFadden and Winston, 1981; Abdelwahab e Sargious, 1992; Abdelwahab, 1998). Logistic decisions comprise a large set of (short and medium



term) decision variables which may interact with the typical transport decisions. For instance, mode choice may depend on shipment size and frequency, which, in turn, interact with the production process. The large data requirement of the disaggregate models could be met via observed, RP (Abdelwahab e Sargious, 1992; Abdelwahab, 1998) or SP data.

**3. States versus revealed preferences**

Observed behaviour reveals human preferences (choices) among a set of available choices. Alternatively, preferences can be inferred from stated choices. A procedure (interview) can be set in which respondents are asked to make choices or state their preferences. The main difference among the RP and SP approach is that the former is based on actual, observed behaviour, while the latter is based on hypothetical, stated behaviour. In other words, the former choice is made in a real market, the latter in an hypothetical market.

The pros and cons of the two approaches, as a basis for analysis and policy decision-making, is widely discussed in the literature. This debate is usually termed as the 'revealed vs. stated-preference' debate (Kopp and Smith, 1993; Louviere, 1996) and it has taken place in various fields, including marketing research, environmental valuation and transportation.

The interest for the hypothetical, stated preferences in marketing research is easily understood, since often production decisions should be taken for newly developed products or products scarcely known to consumers. Therefore, there is the need to know whether the consumer would buy a product characterised by certain features but not available in the market yet. This is done via stated preference interview, also termed conjoint analysis. Similarly, environmental goods are goods or characteristics of goods (e.g., the level of noise of a house) not for sale. How much does the consumer value a reduction of noise or of air pollution? An interview can be performed to ask consumers directly the value they attribute to it. In such a case, the method is termed contingent valuation method (Braden and Kolstad, 1991).

In the field of transportation, analysis were often based on revealed-preference data (e.g., trips made in a given year at a given price, ton-km transported by a given mode, etc.). But in the last two decades, stated preference techniques have been gradually introduced in passenger transport demand analysis and, less frequently, on freight transport demand analysis. The method used, termed stated choice technique, differs from the case of environmental valuation since respondents are asked to choose among alternatives (alternative modes, for instance) with differing attributes <sup>1</sup>. On the basis of their choices, assuming the existence of a specific utility function, the value of the attributes can be statistically determined. The theory and the methodological mechanism is adequately explained, e.g., in a special issue of the Journal of Transport Economics and Policy (JTEP, 1988).

For the purpose of this paper, it is of interest to summarise the pros and cons of the RP and SP approaches as they result from the theoretical debate (Wardmam, 1988). The comparison between RP and SP is graphically illustrated in Table 1.

Pros	Cons
<p><b>Revealed preference method</b></p> <ul style="list-style-type: none"> <li>● Actually made, observed, "real" choices</li> </ul>	<ul style="list-style-type: none"> <li>● Only some attributes are measurable</li> <li>● Need a lot of costly data</li> <li>● Data hard to be collected (e.g. prices are confidential and of commercial nature), lack of sufficient data</li> <li>● Correlation among attributes</li> <li>● Insufficient variability to allow robust estimate</li> <li>● Measurement errors</li> <li>● Unspecified choice set</li> </ul>
<p><b>Stated preference method</b></p> <ul style="list-style-type: none"> <li>● Hypothetical, "stated" choices in controlled experiments</li> <li>● Ability to analyse reaction to future, not existing options</li> <li>● Low cost</li> <li>● Precisely specified choice set</li> <li>● Multiple answers from each respondent</li> <li>● Multiple choice formats (single choice, ranking or rating)</li> <li>● Capability of analysing trade-offs among qualitative attributes</li> </ul>	<ul style="list-style-type: none"> <li>● Hypothetical bias</li> </ul>

**Table 1: RP versus SP data**

As anticipated, the main difference between RP and SP is that the former are inferred from observed choices made in real markets, while the latter are inferred from stated, hypothetical choices made in experimental markets <sup>2</sup>.

The first question is, of course, how reliable stated choices are, how different they are from actual choices. In other terms, is there an hypothetical distortion? The question has no theoretical answer, but only an empirical one, by comparing stated intentions to actual behaviour. The empirical tests so far conducted <sup>3</sup> suggest that "individuals' stated preferences among hypothetical travel scenarios are a reasonably accurate guide to true underlying preferences". Provision could also easily be taken within the questionnaire to check for irrational or inconsistent choices.

Conversely, the hypothetical nature of the experimental market allows one to take advantage of some interesting features of the SP technique since one might:

- get a better feeling of the demand characteristics unrestrained by supply restrictions. The observed choices in real markets are, in fact, the result of the demand-supply interplay. In an experimental market supply restraints can be relaxed;
- test the firm reaction to future, not-existing options;
- present a wider set of alternatives than the ones available in reality, in terms of new modal opportunities or of different characteristics of the existing modes (faster or more reliable trains, inter-modal opportunities, new services, etc.);



- express accurately the characteristics of each option. In fact, actual choices are made on the basis of how a decision maker perceives the attributes of an option, which might differ from the researcher definition of the attributes (for instance, the perceived reliability of a train service might be perceived from the user differently from the one declared by the rail operator);
- use multiple choice formats. Actual choices are definite (a truck or a train is used), whereas in an interview a respondent might be asked, for instance, to rank or rate or choose among alternatives. This allows a better estimation of the trade-offs among attributes;
- collect several answers from each respondent in order to better estimate disaggregate models and, consequently, improve the cost-efficiency of the research<sup>4</sup>. SP data allows also to estimate a separate utility function for each respondent, an aspect which might be useful to identify market segments with homogeneous preferences.

Furthermore, RP data have serious well-know problems in such:

- data might be costly or difficult to collect (e.g. prices

- might be confidential or have commercial value);
- usually only primary explanatory variables are used because they can be expressed in “objective” or “engineering” units while secondary variables (such as, in passenger transport studies, seat design or station facilities) are hardly used (Kroes and Sheldon, 1988);
- there might be correlation among explanatory variables or insufficient variation to allow robust estimates. These problems are avoided in well-specified experimental SP designs<sup>5</sup>;
- and the choice set or the measurement errors might be difficult to specify.

Consequently, SP technique appear an attractive option in order to complement or integrate RP-based studies (Swait, et al. 1994, Stopher, 1998). How much this is true in practice in the field of freight transport demand analysis is what is discussed in the next sections.

#### 4. Stated preference studies of freight transport

Studies of freight transport via stated preference techniques are limited in number. To the best of our knowledge, the studies presented at conferences, and the papers published in journals or as scientific reports are the ones listed in Table 2.

Authors	Issues	Sample	Technique & software
Fowkes and Tweddle (1988)*	Methodological		LASP
Ortuzar and Palma (1988)*	Refrigerated and Frozen Cargo Exports		Paper questionnaire
MVA (1990)*	Cartage distance		Paper questionnaire
MVA/ITS (1990)*	Inter-modality in exports of good from UK to Continent	40 CAPI, executives	Rating – LASP
MVA (1991)	Inter-modality in imports of good from UK to Continent	100 CAPI, executives	Rating
Fowkes et al. (1991)	Inter-modality		Rating – LASP
MVA/TLF (1992)*	Mode choice in bulk goods	50 CAPI, executives	Rating –ASP
de Jong et al. (1992)**	Value of time		
de Jong et al. (1995)**	Value of time		
Widlert and Bradley (1992)**	Value of time		
Fridstrøm and Madslie (1994, 1995)	Own-account versus third party freight transport	300 telephone CAPI	Choice – MINT
Tweddle et al. (1995, 1996)*	New freight mode (Channel Tunnel)	34 CAPI, shippers, freight forwarders and hauliers	Rating – LASP
Gattuso e Pastorino (1996)	Route choice between Sicily-Mainland Italy	Paper questionnaires	Choice
Fosgerau (1996)*	Value of time		
TRT Trasporti e Territorio (1997)	Mode choice	100 firms	Ranking among 8 alternatives
Bolis and Maggi (1998, 1999)	Transport and logistics	22 face-to-face CAPI, logistic managers	Rating – LASP

\* quoted in NERA (1997), \*\* quoted in de Jong (unknown)

Table 2: SP freight demand studies



We summarise the issues analysed, the methodology applied and the results obtained for a selection of the mentioned studies, chosen on the basis of the topic investigated, of the availability and the clarity of the presentation, and of the year of publication.

#### 4.1 Issues

##### *Freight mode choice in the UK*

SP techniques are typically used to identify the factors influencing the freight mode choice, and to assess their relative strength. In the UK there have been several of such applications. We shall illustrate the one on which we have more information (mainly derived from NERA, 1997).

The MVA/ITS (1990) study examines the importance that freight rate, reliability, and transit time represent in the manufacturers' transport mode choice for unitised freight traffic (Lo-Lo containers, unaccompanied Ro-Ro, accompanied Ro-Ro). The purpose is to identify the value users of current modes ascribe to new inter-modal freight services and technologies (swap body system, small container system for less than vehicle load consignments and two different piggyback systems), and to estimate the possibility of road-rail switching, through the implementation of these new technologies. The focus is on exports flows of foods, beverages, paper and board, non-bulk chemicals, automotive components, textile, clothing, minerals, computing and electrical from the UK to the Continent. The SP technique is used because it allows to investigate preferences for services not available in the market yet, an investigation which would have not been possible via an RP approach.

A subsequent study with analogous characteristics was performed by MVA (1991) focusing on imports of the same goods from the Continent to the UK.

The MVA/TLF (1992) study, instead, is carried out to identify and assess the determinants of freight mode choice in the case of bulk products. Particular attention is paid to rail services demand in order to determine the characteristics that need to be improved to match more closely the users (or potential users) expectations. In this case the SP methodology is performed because it allows to focus on the individual firm choice process. The MVA/TLF (1992) study is based on a previous research carried out by Fowkes et al. (1989, 1991) concerning transit time, reliability, frequency, and the value assigned by users to inter-modal systems.

Tweddle et al. (1995, 1996) aim at predicting the effects of the Channel Tunnel opening on the main freight traffic flows. They analyse the possible changes in freight transport demand when the new facility is operating. A Before and an After study is performed to test the reliability of the forecasts obtained through the SP test. The test consists in asking the distribution managers to rate various hypothetical scenarios in terms of cost, transit time, reliability, frequency of collections, and use of inter-modal technologies. Although some discrepancies between the predicted and the actual demand levels do exist, the overall results confirm the usefulness of the SP methodology as a forecasting tool.

*Own-account versus third party freight transport in Norway*

Fridstrøm and Madslie (1994, 1995) analyse the factors influencing the choice between own-account and third party freight transport services in the Norwegian wholesale industry. They study the choice process distinguishing between the long run strategic decision level, and the short run operating decision level. Transit cost, time, punctuality and damage risk are investigated as the reference variables in the short run, while features like the possibility of advertising on the vehicles and drivers availability for other tasks are identified as the relevant variables in the long run.

The SP methodology allows them to analyse in depth the interviewee preferences for the various aspects characterising the two alternatives, rather than just testing his general favour for one of the two, as in the RP approach. Their research aims at a descriptive more than at a predictive function, but, since they use a discrete choice methodology, their results could have been profitably used also as forecasting tool.

##### *Transport and logistics services in the Trans-Alpine Freight Market*

Bolis and Maggi (1998, 1999) investigate the micro dimensions of freight transport demand in a logistic context, using as a sample the Trans-Alpine freight transport market. Starting from the evidence that the shipper's mode choice is part of a more complex logistic decision process, they investigate the role played by standard transport attributes such as cost, transport time, reliability (percentage of shipments arriving on time) and mode, and by logistic attributes such as frequency and flexibility (minimal notice time for transport order in hours). The trade-offs among the variables are then estimated and valued in monetary terms. The impact of the firm logistic approach, and the potential for switching from road to rail in the Trans-Alpine freight transport market are finally evaluated.

#### 4.2 Methodology

##### *UK studies*

The UK studies show many similarities, though they were designed for different purposes. In all the three studies the interviewees were asked to rank (MVA/ITS, 1990 and MVA/TLF, 1992) or to rate (Tweddle et al. 1995, 1996) the various options included in the proposed choice set. The rating methodology is preferred to the pure choice one because more informative about the intensity of the individual comparative preferences for each available alternative, and because more efficient<sup>6</sup>. By "exploding" rating data it is, in fact, possible to transform the ratings into choices, obtaining much more information than from just one observation<sup>7</sup>. Tweddle et al. (1995, 1996) use the following methodology. First, a pre-test concerning the firm's logistic organisation and its typical long distance freight flow is administered in order to learn what are typical and realistic choices made by the firm. Next, the an SP experiment is performed on a portable computer equipped with the LASP (Leeds Adaptive Stated Preference) software. This software uses the information drawn from the description of the typical freight transport, as



a starting point, and as a reference basis for the interview. LASP is an adaptive procedure in the sense that the alternatives proposed sequentially depend on (and are adapted to) the respondent previous ratings. This allows to efficiently reach the indifference level among the available alternatives, discharging those alternatives clearly inferior to the respondent. The ratings given by the respondent are transformed into probabilities by the following formula:

$$\begin{aligned} \text{if Rate A} > \text{Rate B} & \text{ then Prob A} = 1 - 0.5 * \text{Rate B} / \text{Rate A} \\ \text{if Rate B} > \text{Rate A} & \text{ then Prob A} = 0.5 * \text{Rate B} / \text{Rate A} \end{aligned}$$

The corresponding logit transformation is :

$$\text{Logit A} = \log \text{Prob A} / (1 - \text{Prob A})$$

The value of Logit A is then regressed against the differences in the option attributes through the SAS package. The firm's evaluation of the investigated qualities of the analysed freight transportation modes is obtained in terms of the ratio of attribute coefficients to the cost coefficient, that is the monetary value of the qualitative attributes.

#### *Fridstrøm and Madslie*

Fridstrøm and Madslie (1994, 1995) perform their interviews on the wholesalers' sector in order to maintain both the homogeneity with respect to the companies' type of production, and the heterogeneity of the commodity type available on the market<sup>8</sup>. For each interaction the interviewee is asked to choose between two options characterised by different values of the analysed variables. They opt for a pure choice test rather than for a rating or ranking one, as Bolis & Maggi, and Fowkes & Tweddle did instead.

The interviews are performed using a personal computer equipped with the software MINT. The software allows to perform customised and interactive tests. Interviews are customised in the sense that the alternatives are made vary around the values of the shipment and the company characteristics as recorded during an ad hoc pre-test. Interviews are interactive because, exploiting the transitivity assumption, the computer "learns" from previous choices, and the following submitted options narrow gradually the indifference surface.

Fridstrøm and Madslie organise the testing process into two different levels: a strategic one, and an operational one, depending on the temporal horizon and on the importance of the firm's logistic reorganisation implied by the choices offered to the interviewee. During the so called "within mode game" the respondent is asked to choose between two own-account or two third party options, depending on which of the two was in use at the time. With the "between mode game", instead, the respondent is asked to choose between the actually used mode, and an alternative one.

At the first stage interview, they propose to the interviewee nine plus nine different binary choices tests about their willingness to purchase or renew an own vehicle fleet versus a long term agreement with a third carrier. While at the second stage interview they allow the respondent to choose among alterna-

tives available just in the short run (i.e., they vary the short run variables in the definition of the possible option).

To estimate the model, Fridstrøm and Madslie adopt both a parsimonious logit model, which allows to estimate a small number of parameters and which is generally used for forecasting purposes, and an ample one, which is a descriptive rather than a predictive model, and which uses a larger number of variables not necessary exogenous to the freight choice process. TRIO, by Gaudry & al. (1993), is the software used to estimate the coefficients of the independent variables. It allows the user to specify several independent variables as different Box-Cox transformations, the parameters of which are estimated simultaneously with the ordinary coefficients of the logit regression:

$$V_i = \sum_j \beta_j x_{ij}^{(\lambda_j)}$$

where  $V_i$  represents the "indirect utility" function associated with the alternative  $i$ . It is important to underline that with this software they are able to estimate the conditional t-statistic associated with each estimation, beside the marginal rate of substitution of the considered factors in respect to the cost term.

#### *Bolis and Maggi*

Bolis and Maggi perform a face-to-face interview to a random sample of 4 firms in Ticino (Switzerland), while a random sample of 250 firms located in Northern Italy are consulted via postal surveys (of the 250 questionnaire just 24 could be used). They too use the LASP software. In comparison with MINT, the LASP methodology has the advantage of allowing the measure of the characteristics variations in absolute terms, and not just in percentage terms, which is indeed more informative and useful for explanatory and interpretative purposes. Bolis and Maggi separate their analysis into three phases (levels), assuming that the firm's decisions are taken in that order. In the first stage (strategic/long term decisions on location and general logistics) the firm is assumed to define the localisation of its production and warehouse sites and its supplier/client network. In the second stage (strategic/medium term decisions on transport logistics) the firm is supposed to deal with decisions related to its supply chain organisation, warehouse stock level, shipping frequency and dimensions, service flexibility, typology of documents, factoring, tracking and tracing systems, insurance, and money back warranty. In the third stage (operative decisions on transport services) the firm is believed to decide the transport mode, and the logistic service level to be adopted. However, in the empirical application, Bolis and Maggi focus only on the operative and medium term decision stages.

The data collected are analysed in a choice context by "exploding" the data set and then by transforming ratings into binary choices, as done by Fowkes and Tweddle (1996). Having to deal with probabilities, instead of utilities, it is then possible to estimate a logistic regression model, where the coefficients of the parameters represent the effect on the respondent's utility level caused by some change in the correspondent variable. The ratio of the service attributes to the cost coefficient represents



the monetary value at a margin, that is how changes in an attribute is traded off against a monetary change in transport cost.

4.3 Results

UK studies

The studies on mode choice performed in the UK show the potential of SP techniques to obtain a quantitative estimate of the importance of modal attributes, either at an individual or at an aggregate level, for various type of goods. Table 3 summarises the main results at an aggregate level. A disaggregate description of the results is presented in NERA (1997). By dividing the coefficient of each attribute, e.g. reliability by the coefficient of cost as obtained in the regression equation, it is possible to estimate its monetary value (i.e., the willingness to pay for a marginal change of that) attribute. In addition, Fowkes and Tweddle (1988) propose to express all cost units as percentages of the freight rate, in order to simplify the complexities of the various units. Each value is to be interpreted as the percentage discount of the transport cost necessary to be applied in order make the shipper accept an unit increase in each of the listed attributes.

Attribute	MVA (92) (bulk goods)	Fawkes et al. (89,91,92) Untised and bulk	MVA/ITS (90) Unitised Exports <sup>a</sup>	MVA (91)	Tweddle (95,96) Unitised imports
Transit time (half day longer transit time)		13-32%	7.7%	9.5%	5%
Reliability (1% less on time)	1.5%	1-6%	3.9%	3.1%	5%
Flexibility (1 day longer notice)	2.1%				
Intermodality (use of rail)	9.1% <sup>10</sup>	3-14% <sup>11</sup>	-2%	0.1%	21%
1 less collect per week		1.5%			
1 more lifts in transit		2-42%			
Technology (use of Le Shuttle)					6.4%

Source: NERA (1997)

Table 3. Yugoslav Inland Waterways

It results that transit time is a very relevant variable. Operators are willing to accept an half day increase in transit time only if freight rate is reduced by an average of 10%. Reliability is also (encouragingly) consistently valued across studies, about 3% of the freight rate. The value of inter-modal services (the acceptance of use of rail) is quite low. Except in the case of unitised exports in the MVA/ITS (1990) study, it appears that operators are willing to accept to switch to rail services only at large freight discounts. Flexibility is measured at 2% only in one study. As expected, all studies show that different goods have different needs (and constraints), and that the potential for the use of rail differs among regions and corridors. A general conservatism and an evidence of sunk investments is also reported.

Finally, it is worth noting that the results derived from the 1995 study about the prospective of the freight demand as a consequen-

ce of the opening of the Channel Tunnel, matched quite appropriately the actual demand changes. It had been proved, in fact, that the discrepancies were caused by unpredictable public and private market policies (unforeseeable pore quality of the train services and excessively low prices of the available ferry services), rather than by some methodological mistake. This shows a potential for SP studies to be used for predictive purposes.

Fridstrøm and Madslie

As the authors of the Norwegian research underlined, the interpretation and the importance of the results obtained via the above described SP survey should be drowned considering that "complete and relevant RP data sets on desegregate freight market choices are practically non-existent, and very hard to be collected". Under this point of view their conclusions on the Norwegian wholesalers preferences and attitude towards own-account and third-party freight appear even more significant, not just because of the already mentioned advantages of the SP methodology compared to the RP ones, but also because, al least accordingly to Fridstrøm and Madslie, it seems that these are the only desegregate data sets available at the present time.

Fridstrøm and Madslie divide the obtained estimates into two groups, depending on the choice temporal horizon considered, and express those results in terms of willingness to pay for a marginal improvement of each considered variable and in terms of marginal rate of substitution against a variation of the transport cost. A summary of their conclusions is reported in Table 4.

Operational (Shipment) Decision Level

Variable	Relative rate of substitution
Time	<ul style="list-style-type: none"> <li>● higher in short term decision process than in the long one</li> <li>● decreases as the transit time gets longer</li> <li>● higher for fresh comestibles, but negative for frozen combustibles</li> <li>● higher for semi-finished products</li> <li>● not related to the value or the size of the shipment</li> <li>● asymmetrical: high to avoid delays but lower to accelerate deliveries</li> </ul>
Punctuality	<ul style="list-style-type: none"> <li>● higher for comestibles</li> <li>● higher for longer transit time</li> <li>● higher for fixed delivery time</li> </ul>
Damage Risk	<ul style="list-style-type: none"> <li>● less than half of the expected loss</li> </ul>

Strategic Decision Level

Variable (Own-Account versus Third Party)	Relative rate of substitution
Employer's responsibility for drivers Employer's responsibility for cargo Fixed own account freight costs Possible absence of own drivers Availability of multitask drivers	<ul style="list-style-type: none"> <li>● negative but statistically insignificant</li> <li>● negative but statistically insignificant</li> <li>● positive</li> <li>● negative but statistically insignificant</li> <li>● highly significant positive</li> </ul>
Variable (both Own-Account and Third Party)	Relative rate of substitution
Inertia Freight terminal opening hours Vehicles advertising Company size	<ul style="list-style-type: none"> <li>● higher for TP freight users</li> <li>● negative in both cases</li> <li>● not statistically insignificant</li> <li>● preference for TP freight services higher for bigger company</li> </ul>

Table 4: Own-account versus third party freight transport in Norway



Although some of the results seem obvious and quite predictable (for example the recognition of a higher value of time for fresh comestibles or the absence of relation between cargo size and the value of time), other conclusions are less self evident and reasonably unexpected (for example the asymmetrical value of time for delays and for earlier consignments or the fairly low value of damage risk).

Fridstrøm and Madslie analysed both the variables measuring the attitude between own account and third party options (first half of the strategic level results in the represented table), and the general attitude of the wholesalers toward some characteristics of freight transport demand (inertia, vehicle advertising, and so on).

The complexity of the real freight market choice situations required to artificially separate both the hypothesised short term choices from the long term ones and some otherwise naturally interrelated aspects of the logistic chain. The potential bias deriving from this methodology, added to the distortion caused by the analyst lack of knowledge of the decision context and of the individual choice mechanism, question the validity and reliability of the final results.

Even so the SP approach seems to be the only one able to enlighten and investigate the relative importance of the individual preference toward the main factors influencing the freight transport demand.

*Bolis and Maggi*

Bolis and Maggi (1999) results, reported in monetary values in Table 5, are in line with the previous studies.

Value of	CHF/Net ton.
Time	1.15 CHF for 1 hour less in time
Reliability	2.42 CHF for 1% more in reliability
Flexibility	0.37 CHF for 1 hour less in notice time
Frequency	1.10 CHF for one shipment more per month (not significant)

Source: Bolis and Maggi (1999)

**Table 5**

They also calculate the trade-off among rail and non rail modes. They estimate that a firm is indifferent if one of the improvements listed in Table 6 is offered as a compensation.

Value of	
Price	17.14 CHF of rebate
Time	15.5 Hours faster
Reliability	7.5% More reliable
Flexibility	46 Hours in notice time
Frequency	15 Times/months more frequent (not significant)

Source: Bolis and Maggi (1999)

**Table 6**

The logistic variables (flexibility and frequency) have the proper sign, though only flexibility is significant. The experiments they performed let the authors notice that the firms practising Just-in-time (JIT) logistics place a high value on frequency an flexibility. Specifically they notice that “if the interviewed firm itself was practising JIT, the most relevant variable is frequency. If it is the client who is working JIT, the most relevant decision variable is reliability”, demonstrating the crucial role played by logistic choice in shaping transport demand. However, they also conclude that price and time confirm their overwhelming importance in all sub samples.

**5. Conclusions**

Different methodologies have been adopted to analyse the determinants of freight transport demand. Traditionally, economists have estimated freight transport demand models via observed, RP data. The problems encountered anyway are enormous. Abdelwahab and Sargious (1992) publish a paper in which RP-based estimates of a sophisticated inventory model with joint determination of mode choice and shipment size are provided. In that paper they report facing the following difficulties:

- the most recent reliable data for the US are dated back to 1977 (the 1983 date were not published because of poor quality);
- the most disaggregate level is an origin-destination commodity matrix made up of 49 areas. Each consists of a large SMSA (Standard Metropolitan Statistical Area), with 900 or more manufacturing establishments;
- there was lack of data in the database for what concerns the level of service variables, the market attributes or the shipper characteristics. Hence, the database was filled in with data from other sources or from theoretical models developed by various researchers to predict freight transport level of service attributes such as freight charges for truck and rail, transit time and reliability of transit time for truck and rail, susceptibility of a shipment to loss and damage when moved by truck and rail.

The case of ad hoc SP interviews needs not be stressed further. Direct interviews provide an essential source of direct, up-to-date information on individual firms’ preferences for modal attributes, though they pose other, partly already discussed, problems. One of the issues which has not been discussed yet is the aggregatio process. As a matter of fact, SP studies prove to be extremely useful to understand individual firm’s, micro behaviour, but face some little explored difficulties for what concerns the aggregation stage of the estimation process.

Such discussion has already taken place at the theoretical level when comparing disaggregated and aggregated models. Disaggregated models are better-rooted on individual behaviour, but aggregate models, according to some authors (Anas, 1981), can be more useful in the context of large-scale (regional or national) analyses of freight flows when the objective is forecasting or policy analysis. In the same way,



RP studies might be a better base for forecasting or policy analysis, though SP studies provide a sounder tool for understanding firms choices and analysing the trade-off between price and non-price modal choice determinants. As it appears, so far SP studies have been mostly based on rating or ranking formats, which are generally thought more appropriate for trade-off analysis (sometimes termed part-worth analysis), than for modelling and prediction. Moreover, SP studies have focused on few, geographically concentrated interviews segments of the freight market. It would interesting to see the results of an a choice SP study (instead of a ranking or rating one) performed larger sample in order to produce the data needed modelling and forecasting. The availability of cheap portable computers and the growing experience in this research field will certainly allow to conduct such studies in the near future.

There is also a stream of the literature on the factors influencing freight transport mode choice that adopt a more qualitative methodology (see Matear and Gray, 1993, for a review). Shippers or freight suppliers are typically confronted with a large (sometimes open) selection of service attributes including carrier, route, timing, price and control characteristics. As example is Table 7.

Component	Service attributes
Carrier characteristics	Arrival time, good relationship with carrier, fast response to problems, able to handle special requirements, perform urgent deliveries
Route characteristics	Know which port is used, proximity to origin, proximity to port destination
Time characteristics	High frequency of service, on time collection and delivery, short transit time, departure time from origin
Price characteristics	Low price, value for money price, special offers of discounts
Control characteristics	Transport preference of trading partner, documentation completed carrier

Source: Matear and Gray (1993)

**Table 7: Service attributes**

Respondents are asked to rate on a scale (usually form 1 to 5) the importance of each attribute. A principal components analysis is then performed to obtain an average mean score for each component. The pros and cons of such analysis relative to the SP approach are the ones typically identified when comparing qualitative and quantitative methods.

Qualitative studies are very informative and detailed on all nuances of choices, but the information they produce are hard to be synthesised, let alone the possibility of estimating or validating models on such premises. The SP approach trade off the extensiveness of the attributes examined with the possibility of estimating statistically their importance. As a matter of fact statistical estimate provides information not only on the relative importance of the analysed attributes, but also

on their statistical significance (given some assumptions on the error distribution). Hence, the estimation or validation of demand models, the estimation of the implicit monetary value of each qualitative attribute, and the comparisons across studies are allowed.

In Section 4, the studies so far conducted have been briefly illustrated, bringing to the conclusion that the SP methodology yields a better understanding of modal choice, of the prospects for transferring on rail part of the road based transport, of the choice among own and third party transport service and on the interactions among logistic and transport attributes. It seems to us that very informative results can be derived from SP analysis and that previous knowledge derived from RP or qualitative studies can be usefully complemented in a field such as freight transport, where so many economic, geographic, physical, technological variables interact and where very few generalisations can be made. As stated in the introduction, it is particularly difficult to study freight transport demand because of its characteristic of being a derived demand, the heterogeneity of the goods transported, the existence of more than one decision maker, the role of geographic factors, and the use of long term, confidential prices. The SP methodology asks the freighted transport market agent to take part to an experimental game. If the computer possibilities are fully used to design realistic, adaptive and informative games, we believe that much can be learn about how different firms with different characteristics in different settings make choices.

## REFERENCES

- ABDELWAHAB, W. (1998) "Elasticities mode choice probabilities and market elasticities of demand: evidence from a simultaneous mode choice/shipment-size freight transport model", *Transport Research* 34 (4) 257-266.
- ABDELWAHAB, W. AND SARGIOUS, M.A. (1992) "Modeling the demand for freight transport: new approach", *Journal of Transport Economics and Policy*, 26 (1), 49-70.
- ANAS, A. (1981) "The estimation of multinomial logit models of joint location and travel mode choice from aggregate data", *Journal of Regional Science*, 21, 223-242.
- BAUMOL, W. J. AND H.D. VINOD (1970) "An inventory-Theoretic model of freight transport Demand", *Management Science*, 16, 413-421.
- BEN AKIVA AND MORIKAWA (1990)
- BOLIS, S. AND MAGGI, R. (1998) "Adaptive Stated Preference Analysis of Shippers' Transport and Logistics Choice", Paper presented at the 38<sup>th</sup> ERSA Conference, Vienna.
- BOLIS, S. AND MAGGI, R. (1999) "Logistics Strategy and Transport Service Choices an Adaptive Stated Preference Experiment", Paper presented at the 38<sup>th</sup> ERSA Conference, Dublin.
- BOYER, K.D. (1977) "Minimum rate regulation, modal split sensitivities, and the railroad problem" *Journal of Political Economy*, 85, 493-512.
- BRADEN, J.B. AND KOLSTAD, C.D. (eds) (1991) *Measuring the Demand for Environmental Quality*, Elsevier, Amsterdam.
- FOSGERAU, M. (1996) "Freight traffic on the Storebækt fixed link", PRTC, London.
- FOWKES T., NASH, C.A. AND TWEDDLE, G. (1992) "Harmonizing heavy goods vehicle taxes in Europe: A British view", *Transport Reviews*, 12 (3).