# ADAPTIVE STATED PREFERENCE ANALYSIS OF SHIPPERS' TRANSPORT AND LOGISTICS CHOICE

SIMONA BOLIS
MecoP
Faculty of Economics
University of Lugano
Via Ospedale 13, 6900 Lugano, Switzerland
e-mail: simona.bolis@lu.unisi.ch

RICO MAGGI
MecoP
Faculty of Economics
University of Lugano
Via Ospedale 13, 6900 Lugano, Switzerland
e-mail: rico.maggi@lu.unisi.ch

## Abstract

In this paper we propose a microanalysis of freight transport demand. Current research concentrates with few exceptions on shippers' choice of a transport mode and offers consistent evidence on the importance of characteristics. However, with globalised production and liberalisation, the market offers services that range from simple movement to integrated logistics. As a consequence, shippers' behaviour is conceived here as a complex decision, which considers transport mode choice as only a part of a firm's logistics strategy. Since there exists no data to directly estimate the marginal willingness to pay for different qualities of transport and logistics services a stated preference approach is applied. Adaptive stated preference experiments are performed and completed by background information on long term logistics strategy. Here, we present first results combining the outcome of choice analysis with evidence on the cases from which the data has been collected.

## INTRODUCTION

The structure of production, distribution and transport goes through a rapid transition phase. Globalisation, outsourcing and just in time are trends that lead to an increased demand for freight transport on the one hand and to a change in the kind and quality of services demanded on the other. On a European level, the political and economic process of integration and the increase in spatial interaction reinforces these trends. The consequence is an increasing stress on the transport networks in form of congestion and bottlenecks (Müller and Maggi, 1998).

The policy response to these problems is manifold (deregulation, integration of networks, promotion of rail etc.). One of the many open questions, especially in the trans-Alpine context, is the potential of rail and more specifically intermodal transport for helping to solve the problems. It is far from being clear whether railway and combined transport, once the markets are open, would be able to offer competitive services in an economy dominated by flexible, JIT production systems and modern logistics. Hence, it seems interesting to try and answer the question on what determines the demand for freight transport in a logistics context and whether there is a demand for services typically offered on rail.

It is for this reason that we propose an in-depth analysis of freight transport demand. Current freight demand/choice modelling concentrates - with few exceptions – solely on shipper's choice of a transport mode. However, this is not a realistic model of shipper's behaviour. With globalised production and liberalisation, the market offers services, which range from simple movement (traction) to integrated (value-added) logistics in a network context. Hence, the shipper does not only have a choice of transport modes, but can choose among a variety of services in a spatial context including logistics. As a consequence, shipper's behaviour has to be conceived as a complex decision, which considers transport choice as only a part of a firm's logistics strategy with respect to location, supply chain management, production and distribution.

In the literature, there exists consistent evidence across a large number of studies on importance/relevance of characteristics in a transport mode choice context (reliability, price, time, safety) (see Aberle, 1993, NERA, MVA, STM, ITS, 1997). In addition, we find many general arguments on the strategic importance of logistics and its implications for transport decisions. However, there are few convincing attempts to model the decision on transport and logistics services simultaneously (as an exception see McFadden *et al.*, 1985).

This lack of knowledge is critical in a context of heavily regulated transport markets because policy proposals concentrate on new infrastructure and the promotion of rail without a sound knowledge of the factors guiding demand.

This study therefore proposes to analyse demand for transport services defined over a set of variables including logistics in the case of trans-Alpine Freight Transport (TAFT). Demand is confined to shippers. They want to have the provision of their inputs and the distribution of their freight performed with a certain quality.

Since there exists no data to directly estimate the marginal willingness to pay for different qualities of TAFT services a stated preference approach seems appropriate. An adaptive stated preference experiment will be performed in order to capture the specific context for each interviewed firm. The evidence will be completed by background information on these firms.

This research strategy offers an appropriate survey instrument to overcome market intrasparencies and a lack of data that characterises TAFT. Furthermore, the overall research should confirm if a stated preference approach could serve as a useful theoretical background for the analysis of quality oriented markets.

In this paper we first present a simple theoretical model serving as a reference for the arguments. It follows a presentation of the decision structure of a modern shipper in terms of logistics and transport. Supporting evidence on the top layer of these decisions, i.e. the long term spatial and logistics strategies, is presented subsequently. The empirical analysis describes the data gathering in form of an adaptive stated preference experiment by which we collect data on decisions on transport and logistics, the two lower levels of the decision tree. Then, first results combining the outcomes of the econometric analysis with evidence on the cases from which the data are collected are presented. Finally, first conclusions are drawn.

## THE THEORETICAL MODEL

The background for our model is an industrial firm. Our simple model has two distinctive features:

- We integrate transport and logistics services as a production factor (input), and
- We conceive a firm as a network (output characteristic).

Starting from a general production function and its dual, the cost function, we derive the factor demand for transport and logistics services (see Seitz, 1993).

The simple production function is:

$Q = f(L, K, A, N)$ where

| | | |
|---|---|---|
| Q: | Output |
| L: | Labour |
| K: | Capital |
| A: | Transport and Logistics services |
| N: | Network structure |

Network structure captures the spatial organisation of the firm (location of plants, raw material suppliers, market outlets etc.) as well as long term logistics decisions (distribution of warehouses, organisation of the supply chain etc.). The inclusion of this "output characteristic" permits to identify impacts of strategic location and logistics decision on the demand for transport and logistics services (see Filippini and Maggi, 1992).

Considering transport and logistics services as an input makes it possible to analyse the demand for it as a function of its price and characteristics but also in relation to the prices of the other factors.

We believe that this kind of production function gives a realistic picture of a modern firm.

The dual to the above production function is the following general cost function:

$C = f(Q, P_l, P_k, P_a, N)$ where

| | |
|---|---|
| C: | Cost |
| $P_l$: | Price of Labour |
| $P_k$: | Price of Capital |
| $P_a$: | Price of Transport and Logistics services |
| N: | Network structure |

$P_a$ is a hedonic price i.e. a (non-linear) function of the levels of the characteristics of the services:

$P_a = f(C_1, C_2, \ldots, C_n)$ where: $C_n$: Service Characteristics

Taking the first derivative of this cost function with respect to transport cost, we get (conditional) factor demand as:

$dC/dP_a = A = f(Q, P_l, P_k, P_a, C_1, C_2, \ldots, C_n, N)$

In reality, A is demand for a specific transport and logistics service selected by the firm. As the firm can choose the type of service, the price characteristics vector is endogenous, i.e. depending on the firm's choice (see Rosen, 1974). Hence A is indexed on having chosen service i:

$A^i = f(Q, P_l, P_k, P_a^i, C_1^i, C_2^i, \ldots, C_n^i, N)$ i = specific transport and logistics service

It would in principle be possible to endogenise N but we consider this as a long run strategic choice and prefer to concentrate on short and medium term decisions.

In the above form, the decision taken by the shipper is discrete/continuous – the firm decides on a specific service as well as on the quantity demanded of this service. It is open to estimation using one of the different approaches combining discrete and continuous decisions.
If it is possible to observe all the above variables we can estimate factor demand as a part of the allocation decision of the firm. If it is only possible to observe the transport/logistics related variables, we have to restrict the analysis to this factor. This implies assuming strong separability of the production function.
Here, we will restrict our analysis to transport and logistics services. Moreover, in a first step only the choice of a specific service will be modelled.
Hence, the integrated model of transport and logistics choice applied here can be embedded in a traditional economic context and will permit to include network characteristics. The latter is being determined by the long-term strategic decision of the firm.
In the sequel we will have to identify an appropriate vector of transport and logistics attributes to be included in the analysis.

## INTEGRATING TRANSPORT AND LOGISTIC CHOICE: EMPIRICAL APPROACH

For the purpose of this study we start from the following three layers decision structure:

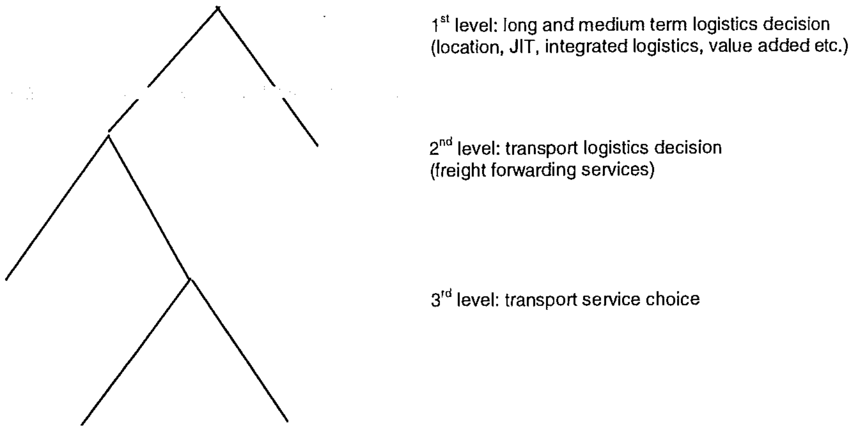


**Figure 1 – The Transport and Logistics Decision Structure**

On the third level, the shipper decides on the transport service only. Examples for characteristics included are: price, transport time, reliability, safety. These characteristics are implied in a specific transport mode. In so far as shippers have preferences for modes as such, the mode enters as an additional quality. On the second level shippers decide on the transport logistics. Examples for relevant characteristics are: price, stock in warehouses, frequency and dimension of shipping's, flexibility of the service, documents (paper, electronic), factoring (prepaid, collect), tracking/routing, insurance, money back warranty. The first level concerns the medium and long-term logistics choice. Characteristics are: price, warehousing logistics, value added services, packaging.
Summarising, the decision levels are:

1. Strategic/long term (general logistics decisions in the long run)

The company defines its own strategic logistics in terms of localisation of the company, supplier/client network and production. The pressure to implement innovative solutions depends on the degree of competition a firm is exposed to.

2. Strategic/medium-short term (transport logistics in the medium run)

The choice of transport logistics is strictly dependent on the choice of the company regarding its logistics.

3. Operative (transport service decisions in the short run)

Within the transport logistics chosen, the transport service decision is strictly dependent on the quality of the service.

## Inductive evidence on the 1st level

Given that in the following section we want to concentrate on decision levels 2 and 3, it is critical to have more information on the content of the first level, i.e. the long-term context. This will help us to control for the relevant influences on the transport and logistics decision stemming from the first level.

In order to collect evidence - in a trans-Alpine context – on the content of the decision to be modelled, in depth interviews with four different firms in Ticino (Switzerland) and a postal survey among shippers in Northern Italy were performed. 250 questionnaire have been sent out to a random sample of firms provided by the Chamber of Commerce of Lombardy. 24 questionnaires could be used. The aim was to assess the decision structure described above.

The main points emerging from the interviews and the postal survey show that the transport logistics solutions adopted strictly depend on the general logistics strategy of the company, which includes the organisation of supply, production and distribution.

The decision about transport, therefore, is not simply dependent on the characteristics of the transported good (often approximated by the sector) and on the attributes of the mode of transport, but on the general logistics concept implemented by the company, at a strategic level, to control the flow of goods (large/small quantities, long/short distance, number of raw materials, frequency of distribution, number and location of plants and warehouses). The logistics of transport involves the definition of how the company receives its supplies and how it distributes its products.

The sophistication of the logistics concept depends on the degree and type of competition the company is exposed to. In the first place, regarding the degree and type of competition the company has in the sector, it has been found that the development of and focalisation on logistics concepts, in particular the use of innovative solutions, is found in sectors where competition is intense and the competitive variable is quality. In this context, logistics represent a competitive instrument for product differentiation. Less importance is given to innovative logistics solutions in sectors where price is the central competitive variable. Secondly, the presence of the company in markets with global competition determines the degree of implementation of new logistics concepts.

The force of competition makes companies optimise production efficiency and adopt new production techniques, which have an impact on transport logistics, above all, from the point of view of supply. JIT production techniques mean the reduction/elimination of stock and therefore immobilisation of capital and the costs of managing the warehouse but impose maximum efficiency in managing the flow of goods. Companies are therefore looking for new, innovative solutions, which meet the new needs of regularity, flexibility and frequency.

On the demand side, competition requires the adoption of new criteria in quality, not only in production but also in distribution. The impact on distribution is underlined by an increasing demand for reliability. This is particularly evident in markets with non-standardised products with competition not only on price, but also on quality, where quality includes the availability of a product at specific points in time and space. On the other hand, in traditional markets, where the central competitive variable is again price, decisions regarding transport still essentially depend on comparing different forms of transport.

At present, as far as land transport is concerned, only the road network can guarantee these new solutions and the needs required. In other words, the flexibility of road transport allows to quickly supply satisfactory solutions with modest investment. Road transport easily adapts to the new requirements of companies without particular difficulty. Within the framework of the new types of organisation which companies are developing, road transport guarantees regularity, frequency and flexibility, which are indispensable to JIT production systems. In particular, the supply of products which have to be brought directly into the production line.

According to our evidence, the specificity of transport logistics depends only marginally on the type of product; it is, on the other hand, more dependents on the distance of markets and their penetration complexity. Having defined the logistics of transport, choosing the mode of transport depends on the quality of the service. Increasing global competition forces companies to focalise on their core business, which provokes an outsourcing of logistics.

Summarising, the survey data confirm that the most important qualities of this service are reliability, followed by price, speed and safety. This confirms the results of recent European surveys where reliability was shown to be one of the most important criteria for the choice of transport (see i.e. Fowkes *et al.*, 1991).

The survey confirms also the relevance of new logistics for supply with a tendency to reduce the number of suppliers and their concentration in limited markets which are regional or supranational. In particular, a connection is shown between supply and distribution networks, defined by the distance and the complexity of market penetration and the solutions in terms of transport logistics adopted by the company: when distances and the complexity of market penetration increase, companies tend to use specialised intermediaries and to reduce unflexible transport systems.

In other words, when the complexity of the production network increases, systems of transport, though relatively economically competitive, such as intermodal transport over long distances, are used less because of their lack of flexibility.

Regarding forwarding agents, contrary to what one might imagine, they are used for secondary services but not as intermediaries in the chain of transport, able to make autonomous decisions about the mean and organisation of a single consignment.

It is interesting to note that the transportation of consumer goods is completely mono-mode: the reliability of the road system is of primary importance to those companies which directly distribute to the consumer.

## EMPIRICAL ANALYSIS USING ADAPTIVE STATED PREFERENCE TECHNIQUES

The empirical strategy implemented is based on the theoretical model presented and the inductive evidence collected and presented above. The aim of the empirical part is to estimate the preferences of shippers for a vector of transport and logistics characteristics. This should permit to calculate relevant behavioural elements in terms of elasticities, values of time etc. in freight transport in general and more specifically in trans-Alpine freight transport.

To perform our analysis we have chosen to use Stated Preference (SP). Revealed Preference (RP) which would be based on observed behaviour is not feasible in our context of freight transport. Data on actual choices is usually commercially very sensitive and hence in a liberalised environment it is no longer possible to obtain information on prices charged for the movement of freight. Freight rates are individually negotiated and held commercially confidential. Apart from the price variable the complexity of the freight transport decision would required to collect a large number of variables and to observe a large number of decision of firms in order to take account of the heterogeneity of the context. Another reason for not using RP is the very limited use of rail based modes (including combined transport). The fact that we have an existing alternative which is not sufficiently used is analogous to analysing the choice of a new alternative (see Tweddle *et al.*, 1996).

For all these reasons we have opted for SP analysis. SP analysis is already well established in freight transport (see Bates, 1988, Fowkes and Tweddle, 1997). The experience is generally positive and it will be possible to build upon these experiences.

There is one drawback on the existing research, however. All evidence known to us is on mode choice. Hence, we have to construct a new model adapted for a more complex decision.

In addition, we can not use traditional conjoint measurement techniques because the choice set has to be adapted to the real context of the decision-maker interviewed. A traditional design would risk to confront the decision-maker with choices/options which are irrelevant for him. For this reason we have to use the so-called Adaptive Stated Preference technique (ASP).
The ASP starts from an existing freight transport option chosen by the interviewed person. Usually this option is elaborated in discussion with the logistics respondent and it describes a typical transport for this firm (see Fowkes and Tweddle, 1996).
Starting from this option, the ASP exercise implies asking the respondent to rate various hypothetical alternatives for performing the same transport task, expressed in terms of the relevant attributes.

## The ASP experiment

In our context of transport and logistics choice the ASP experiment has taken the following form: in a first step the general logistics strategy of the firm is assessed. This gives the relevant context of the 1st level of our choice model, in a second step a typical transport is identified in terms of the variables relevant for the transport and logistics decision (levels 2 and 3).
These variables are:
Transport: cost, time, reliability and mode
Logistics: frequency and flexibility.
In this way we are effectively reducing the choice levels to 2, one outside the experiment and one within. The way the experiment is implemented can best be illustrated on the background of the software we used: Leeds Adaptive Stated Preference Techniques (LASP). The experiment and estimation performed follow very closely the work done by Fowkes and Tweddle (1996). We prefer the LASP software to Hague Consulting's MINT software because it permits not only a variation of characteristics in percentage terms.
The experiment is performed on a portable computer. The screen shows three options; each described with the attributes above. The typical service described (current service) appears in column A and has a fixed rating of 100. The task to perform during the experiment is to assign ratings to hypothetical options presented on the screen, hence the respondent is asked to rate option B and C with respect to A on a scale such that option A (current option) is 100 and option A at half its price would be 200, and option A at double its price would be 50. This is a linear-in-logs scale, but the important thing is that respondents should rank options in their desired order, and use the rating scale to roughly indicate their strength of preference (see Tweddle *et al.,* 1995).
Once the rating on screen one (iteration one) is performed, the following screen offers two new options in column B and C while column A remains reserved during the whole experiment for the reference option.
At the first iteration the respondent is confronted with an option B that is cheaper but slower and options C which is cheaper but less reliable.
In the following iteration the cost variable changes as a function of the rating given until a point of indifference is reached. At this point the following screen will present options where the remaining attributes change following the same procedures. The attributes changed first are those referring to transport, then once convergence is reached those referring to logistics (flexibility and frequency). Finally, the chosen transport mode is varied.
This procedure reflects our modelling concern in several ways. First, we can integrate transport and logistics. Second, whether the transport decision is separated from the logistics one is an outcome of the experiment. Thus, transport mode looses its dominant role and enters as a simple characteristic of the transport service. Given our interest in the matter, combined transport is one of the transport modes presented.
Where possible, two of these experiments will be performed for each firm, one on the supply side and one on the demand side. The aim is to have at least one trans-Alpine transport freight movement per interview.

The whole experiment takes a maximum of 1 hour; the target person is the logistics and distribution manager of the firm.

## FIRST EMPIRICAL EVIDENCE

The results for four firms transporting two commodity groups are presented here. Using the adaptive stated preferences (ASP) experiment described above we obtain values of the rate reduction necessary to compensate for longer transit time, poorer reliability, lower frequency, longer flexibility, and use of different modal systems. For the moment we can not perform cross section estimations in order to identify firm specific first level effects, most importantly the network effect. We have chosen, therefore, to present the results in form of four cases. This also takes into account that long term decisions are too complex to be modelled in a stated preference context. In this sense the combination of estimation results and case study evidence seems appropriate. In the final step the study will cover a range of commodities, representative of various industrial sectors.
As described above, we perform our interviews with the logistics or distribution manager who could answer questions about the distribution and the input activities of the firm.
First, we asses the general logistics strategy of the firm in term of location of production centres, depots and distribution methods, number of suppliers and clients and their spatial distribution.
Second, four regular typical movements were identified, two for the supply side and two for the distribution.
Finally, we perform the experiment, where possible, for two typical transports: the first on the distribution side and the second on the supply side.
The data collected were analysed in a choice context by "exploding" the data set and then transforming ratings (utilities) into binary choices (see Fowkes and Tweddle, 1996).
Turning to the standard approach of choice theory applied to mode choice, the (indirect) utility $V_{in}$ of decision maker n deriving from alternative i is defined by a function:
$V_{in}= f(z_{in},S_n)$
where $z_{in}$ is a vector of the attribute values of alternative i as viewed by decision maker n and $S_n$ is a vector of the characteristics of the decision maker n (or his firm).
In a random utility context and assuming that the unobserved errors are independent and identically Gumbel distributed we can formulate the decision taken by our interview partners as a binary logit model. The probability of individual n choosing alternative A rather then B becomes:

$$P_{nA} = \frac{\exp[V(z_{nA},S_n)]}{\exp[V(z_{nA},S_n)]+\exp[V(z_{nB},S_n)]} = \frac{1}{1+\exp[V(z_{nB},S_n)-V(z_{nA},S_n)]} \quad (1)$$

Choosing a linear form for V we can proceed by taking pairs of alternatives and calculate the difference in the variables between each proposed alternative and the reference alternative A (e.g. $COST_B - COST_A$ ,$TIME_B$- $TIME_A$).
The rating exercise involved 20 interactions. Thus, we observe 40 such differences for each firm. Following Fowkes and Tweddle, for any given pair, the rating was converted into a probability of choosing alternative A according to:
If Rating < 100 then $P_A$= 1- (0,5 Rating/100)
If Rating > 100 then $P_A$= (0.5 *100/Rating)
Proceeding this way we observe probabilities and hence we can estimate a logistic regression model. Transforming the above logit probability we obtain:

$$\text{Log } (P_A/1-P_A)= V(z_{Bn},S_n) - V(z_{An},S_n) \quad (2)$$

Given that with only four observations we can not perform cross-section regressions the $S_n$ are not included and the logistic regression becomes:

$$\text{Log}(P_A/1-P_A) = \beta_1(COST_B - COST_A) + \beta_2(TIME_B - TIME_A) + \beta_3(RELIA_B - RELIA_A) + \beta_4(FREQ_B - FREQ_A) + \beta_5(NOTICE_B - NOTICE_A) + \beta_6 DUMMROAD + \beta_7 DUMMACC \quad (3)$$

where:

| | | |
|---|---|---|
| COST | = | transport cost in 1000 ITL for a door to door service, |
| TIME | = | scheduled journey time in hours between origin and destination, |
| RELIA | = | expected number of shipments per year arriving on time in %, |
| FREQ | = | number of shipments per month, |
| NOTICE | = | minimal notice time for transport order in hours, |
| DUMMROAD | = | 1 if road transport, 0 otherwise, |
| DUMMACC | = | 1 if multimodal transport, 0 otherwise. |

Travel cost and travel time are defined as door to door cost and time, including transhipment. "Notice" is our inverse measure of flexibility.
Furthermore, the following weights were used:
If $Rating_i > 100$ then $W_i = 100/Rating_i$, else $W_i = Rating_i/100$

This gives most weight to the least clear-cut decision. In other words, small changes in rating close to 100 are likely to be a lot more significant than similar changes in other ratings (see Fowkes and Tweddle, 1996).
The results of the estimation are shown in table 1. All coefficients refer to the effect of some change in the respective variable on the respondent's utility (rating). The results presented in Table 1 confirm the findings of others studies (see NERA, MVA, STM, ITA, 1997, Jong and de Gommers, 1992) on the benefits that the user may derive from savings in transport time. Time savings not only reduce the inventory interest charges, which for certain products could amount to a substantial sum, but also help to improve the reliability that has become central to time-sensitive delivery (see O'Laughlin *et al.*, 1993).
Furthermore, there is evidence that service factors such as notice time, reliability, frequency, as well as the standard elements of travel time and cost play a significant role in the choices of users.

**TABLE 1 - Estimation Results on ASP Data (t-values in parenthesis)**

| | CASE 1/a Input TAFT Flow | CASE 1/b Distribution TAFT Flow | CASE 2 Distribution Regional Flow | CASE 3 Distribution TAFT Flow | CASE 4 Distribution TAFT Flow | Exp. Sign |
|---|---|---|---|---|---|---|
| Intercept | 0.677567<br>(5.515) | 1.120011<br>(4.288) | -0.353499<br>(-2.779) | -0.039843<br>(-0.128) | 0.085330<br>(0.433) | |
| Cost | -0.001297<br>(5.515) | -0.005037<br>(-4.841) | -0.001069<br>(-2.779) | -0.0023496<br>(-2.174) | -0.003025<br>(-2.498) | - |
| Time | -0.004988<br>(-7.231) | - 0.012726<br>(-1.983) | -0.041767<br>(-9.198) | -0.002943<br>(-0.471) | -0.015304<br>(-3.530) | - |
| Reliability | 0.025497<br>(1.545) | 0.011793<br>(0.316) | 0.004229<br>(0.209) | 0.026948<br>(0.583) | 0.0811<br>(3.341) | + |
| Frequency | No variations | 2.282992<br>(6.535) | -0.227844<br>(-2.727) | 0.130831<br>(3.021) | 0.023694<br>(1.183) | + |
| Notice Time | -0.001277<br>(-1.032) | -0.009070<br>(-0.703) | -0.007900<br>(-2.404) | -0.021630<br>(-2.393) | -0.146530<br>(-2.812) | - |
| Use of Road | -0.713710<br>(-6.626) | -1.169023<br>(-4.891) | 0.270837<br>(2.399) | 0.213900<br>(0.886) | 0.427077<br>(2.821) | ? |
| Use of Combined Transport | 0.168128<br>(1.891) | -1.224533<br>(-4.298) | -0.187862<br>(-1.255) | 0.373548<br>(1.639) | 0.406843<br>(3.187) | ? |
| R2 adjusted<br>Obs | 0.689<br>40 | 0.587<br>40 | 0.804<br>40 | 0.387<br>40 | 0.429<br>40 | |
| Value/Tonne | 6,25 Mio./Lit. | 7,715 Mio./Lit. | 4 Mio./Lit. | 33,3 Mio./Lit. | 11,25 Mio./Lit. | |

The ratio of the service attributes to the cost coefficient returns the monetary values of an attribute at the margin and hence gives an idea of how changes in attributes are traded off against a monetary change in transport costs. In the case of time this is the Value of Time (VOT). For example for Case 1/a the VOT is 3.845: one hour more in transport time yields the same disutility as Lit.3.845 more in terms of transport cost. In analogy, the valuation of reliability is: 1% less reliability (% of consignments arriving on time) yields the same disutility as Lit.19.653 more in terms of transport cost.
The results for all significant ratios are presented in Table 2. The findings on the trade-off ratios confirm the results of similar research carried out in a European context (see Blauwens and Van de Voorde,, 1988, Winter, 1995, Fowkes and Tweddle, 1997, Jong and de Gommers, 1992, NERA, MVA, STM, ITS, 1997, Hauser and Hidber, 1996, etc.).

**TABLE 2 - ASP Attribute Service to Cost Trade-Off Ratio**

| | CASE 1/a Input TAFT Flow | CASE 1/b Distribution TAFT Flow | CASE 2 Distribution Regional Flow | CASE 3 Distribution TAFT Flow | CASE 4 Distribution TAFT Flow | AVERAGE |
|---|---|---|---|---|---|---|
| Time | 3.845 | 2.525 | 39.008 | - | 5.066 | 12.611 |
| Reliability | - | - | - | - | -26.854 | -26.854 |
| Frequency | - | -453.047 | 212.348 | -55.555 | - | -98.751 |
| Notice Time | - | - | 7.390 | 9.230 | 4.834 | 7.151 |

## Discussion

Because we hypothezise that the relative importance of the attributes is dependent on the characteristics of the different firms, we discuss here the above results against the background of information about the general logistics (1st level of decision).

### CASE 1

**Firm:** Sector: mechanics; Product: washer; Supply Structure: limited number of suppliers, spatially concentrated, regional market; Distribution Structure: limited number of clients, spatially concentrated, above all national market; Production: 90% for stock, 10% on order; Number of production centres: 1; Number of depots: 2.

**Typical Transport:** *Input Side;* From Plettenberg (G) To Lecco (I); Via: Brenner; Distance: 810 km; Volume: 8 tons; Mode: road; Transport performed by: forwarding agent; Shipments per Year: 6 (every two months). *Distribution Side*: From Lecco (I) To Bourbon Lancy (F); Via: Fréjus/Mont Blanc; Distance: 610 km; Volume: 3.5 tons ; Mode: road; Transport performed by: forwarding agent; Shipments per Year: 20 (every 15 days).

Due to the low value of the products, and a substantial volume and availability of storage, the interest in transport and logistics characteristics of this firm is low. On the input side a shipment free on board (FOB) contract makes that cost per shipment is the prime consideration of this firm. On the distribution side, large stocks and a contract with a large foreign client on a yearly base have a similar effect. Exceptions are time (on both sides) and frequency on the distribution side. Today's congested and/or inefficient transport systems result in a situation where firms do in general not get the desired transport time and hence are willing to pay a positive price for an improvement in this quality. The values of time are similar on the input and distribution side and are comparable to those found in similar studies but lower than those observed for the other firms in our sample. The positive sign of the frequency coefficient in equation 1/b indicates that frequency is relevant given the type of contract (regular supply to a large firm that has implemented a JIT production process).

**CASE 2**

**Firm:** Sector: chemical; Product: polyethylene (semi-manufactured); Supply Structure: limited number of suppliers, spatially concentrated, long distance, international markets; Distribution Structure: limited number of clients, spatially concentrated on regional markets; Production: JIT system, 100% on order; Number of production centres: 1; Number of depots: 0.

**Typical Transport:** *Distribution Side;* From Como (I) To Vercelli (I); Via: Milano/Novara (I); Distance: 110 km Volume:1.5 tons; Mode: road; Transport performed by: road haulier; Shipments per Year: 30 (three times a month).

The firm is characterised by small consignments, JIT production and regional distribution flows. The clients are working JIT as well. Accordingly, and in contrast to the first case, this firm attributes a high value to the characteristics, with the exception of reliability.

Because of the low level of stocks, the manufacturer is willing to pay an extra Lit. 39'008 for one hour less in transport time. This value of time is ten times higher than the one in the first case on the input side. JIT does not only mean low or no stocks, but production on short notice. Hence, time is critical and the argument of the warehouse on wheels irrelevant. The value of notice time is Lit. 7'390 for one hour less of pre-announcement time for the order. Notice time has, in contrast with our expectations, a significantly negative sign. Given the JIT context and in order to assure flexibility, we hypothesise that the firm has to buy more frequency than would be optimal. A reduction in frequency would be preferred (Lit. 212'348 for one transport in less per month) but would have to be compensated by more flexibility (shorter notice time). Surprisingly, reliability is not significant. In compensation for the high level of flexibility (pre-announcement time of 3 to 4 hours) the firm is actually working with, a low degree of reliability (only 73% of the shipments arrive on time) is accepted by the firm.

**CASE 3**

**Firm:** Sector: mechanics; Product: valves; Supply Structure: high number of suppliers, spatially diffused, regional and international market; Distribution Structure: high number of clients, spatially diffused, international markets; Production: JIT system, 100% on order; Number of production centres: 1; Number of depots: 1.

**Typical Transport:** *Distribution Side;* From Bergamo (I) To France/ Nord-East Regions; Via: Mont Blanc; Distance: 850/950 km Volume: 0.6 ton; Mode: road; Transport performed by: forwarding agent; Shipments per Year: 100 (by-weekly).

Production is on order and therefore delivery requirements may be tight. This explains the relatively high value of flexibility (reduction of notice time) and frequency as in the second case. In contrast to case 2, however, time and reliability are irrelevant. This may be due to a lack of perception of the importance of these attributes caused by the fact that the firm has outsourced transport services to one single forwarding agent while production related logistics (frequency and flexibility) are remaining in their decision domain and have a high value.

**CASE 4**

**Firm:** Sector: chemical; Product: polyester for graphic work ; Supply Structure: limited number of suppliers, spatially concentrated, long distance, international market; Distribution Structure: high number of clients, spatially dispersed over long distance markets; Production: 50% on order and 50% for stocks; Number of production centres: 2; Number of depots: 2.

**Typical Transport:** *Distribution Side;* From Bergamo (I) To Paris (F); Via: (?); Distance: 890 km; Volume: 0.8 ton; Mode: road; Transport performed by: road haulier; Shipments per Year: 180 (tri-weekly).

Case 4 shows one distinctive feature compared to the others. Reliability is of utmost importance. The firm is serving directly final consumption on a foreign market. It is willing to pay five times as much for 1% more of consignments per year arriving on time than for one hour reduction of transport time (where the value of time is Lit. 5'066). The pressure on behalf of the clients creates also a high need for flexibility (short notice time) in response to unexpected changes in final consumption.

The results on the transport modes give some interesting indications. Though in all five cases the actual typical transport from which the experiment started was road, and our intuitive evidence resulted in a clear dominance of this mode in our context, the road dummy shows a significant positive sign in only two cases while the sign is significantly negative in two other cases and not significant in the fifth. Based on this very preliminary evidence, we conclude that the predominant use of road transport is caused by current restrictions rather than by a mode specific preference. If this result is confirmed, we will also be wondering whether the procedure chosen here, i.e. presenting the mode not as a label characterising an alternative but only as a further characteristic does lead to more realistic estimates of taste shifters. A significant preference for combined transport over the pure rail alternative is found only in one case.
These case studies confirm one of the main advantages of using ASP, that is, it can handle different decision contexts and returns individual valuations. Estimates for individuals produced by ASP are not always very precise, the following step of our research will be to perform cross-section estimations with a sample of about 20 firms. This will allow us to check these preliminary results and include firm specific variables into our analysis.

## CONCLUSIONS

In this paper we presented first evidence on a model of freight transport and logistics service choice of shippers. The objective of the research is to produce realistic estimates of the determinants of service choice in order to guide rail-related strategies in trans-Alpine freight transport. From a theoretical point of view, transport and logistics services are considered as production factors of a firm. This specification, together with the integration of the spatial structure of the firm as an output characteristic permits to set our model in a traditional microeconomic setting. Inductive research in Southern Switzerland and Northern Italy permitted to identify three relevant decision levels of a shipper: general spatial structure and logistics, transport logistics, and transport services. It was found that the degree to which shippers implement modern logistics solutions depends less on the sector but rather on the degree of competition a firm is exposed to. The adaptive stated preference experiments performed so far with four firms allowed for estimation of simple logistic regressions on a binary choice among different services. A specificity of the SP design chosen here is that the transport modes enter as a simple quality of a service rather than as a label. With this we tried to avoid an explicit focus on a choice among modes during the experiment.
The results demonstrate a value of time that is comparable to those found in other studies but varies significantly among shippers. It is interesting to note that JIT is not reducing but increasing the value of time. This finding which is in contrast with the often-heard argument of the warehouse on wheels will need confirmation in the continuation of the research. A second interesting finding is that reliability is a significant quality only in one out of five experiments. Availability (in terms of percentage of consignments arriving on time) can, according to our results, be either bought by outsourcing transport or can be substituted by high frequency and flexibility.
Overall the first evidence is encouraging and offers some understanding of the determinants of the transport and logistics choice. The empirical evidence suggests that the freight rate is not the only determinant on transport choice. Frequency and flexibility are shown to be very important and necessary a basis for transport and logistics choice analysis. However, the main conclusion is that the relative weight of each attribute is not dependent on the kind of goods or on the sector but the transport choice is strictly dependent on the general logistics of the firm. This is true for frequency

and flexibility. The estimations confirm the high variability of important attributes, different firms have different logistics structures: that means different needs and constraints. Furthermore specific attributes are necessary to meet specific needs of the firm.
The next steps foreseen are to perform cross section analysis in order to integrate the third level of decision in form of network variables. Moreover, the choice model will have to be adapted to test for the relevance of the decision structure. Finally, the results will have to be transformed into policy relevant elasticity estimates and more attention will have to be paid to mode specific preferences.

## ACKNOWLEDGMENTS

The authors are indebted to Tony Fowkes and George Tweddle from the Institute of Transport Studies of Leeds who provided us with the software. Their support is gratefully acknowledged. Our thanks go also to Kay Axhausen, Innsbruck, Michel Beuthe, Mons, and Eric Verhoef, Amsterdam for their helpful comments.
This research is performed with a grant from the Swiss National Science Foundations Programme on "Transport and the Environment", and with financial support from the European action COST 328.

## REFERENCES

Aberle, G. (1993) **The Social Benefits of the Long-Distance Road Transport of Goods**, International Study Commissioned by the International Road Union (IRU), Géneve.

Bates, J. (1988) Econometric Issues in Stated Preference Analysis, **Journal of Transport Economics and Policy**, Vol. 22 n.1, pp.59-68.

Blauwens, G., Van de Voorde, E. (1988) The Valuation of Time Savings in Commodity Transport, **International Journal of Transport Economics**, Vol. XV, N.1, pp.77-87.

Filippini, M. and Maggi, R. (1992) The Cost Structure of the Swiss Private Railways, **International Journal of Transport Economics**, Vol. XIX- N.3, pp.307-327.

Fowkes, A.S., Nash, C.A. and Tweddle, G. (1991) Investigating the Market for Inter-Modal Freight Technologies, **Transportation Research A**, Vol.25A-4, pp.161-172.

Fowkes, A.S. and Tweddle, G. (1996) Modelling and Forecasting Freight Transport Demand, Mimeo.

Fowkes, A.S. and Tweddle, G. (1997) Validation of Stated Preference Forecasting: A case Study Involving Anglo-Continental Freight, **Transportation Planning Methods**, Vol. II (code P415), proceedings to Seminar F. 25$^{th}$ European Transport Forum, published by PTRC Education and research service Ltd, London, pp.173-189.

Jong, G.C. de, Gommers, M.A. and Klooster, J.P.G.N. (1992), Time Value in Freight Transport: Methods and Results, PTRC – *Summer Annual Meeting*, UMIST, PTRC, London.

Hauser, G., Hidber, C.F. (1996) Der Wert der Zeit im Güterverkehr, in Fischer G., Lässer Ch., (eds.) **Theorie und Praxis der Tourismus- und Verkrhrswirtschaft im Wertewandel**, Paul Haupt, Bern/Stuttgart, pp.263-276.

McFadden, D., Winston, C., and Boersch-Supan, A. (1985) Joint Estimation of Freight Transportation Decisions under Non-random Sampling, **Analytical Studies in Transport Economics**, A. Daughety (ed.), Cambridge University Press, Cambridge.

Müller, K. and Maggi, M. (1998) Price Effects of Regulation, in A. Reggiani (ed.), **Accessibility, Trade and Location Behaviour**, Ashgate, Aldershot.

NERA, MVA, STM, ITS (1997), **The Potential for Rail Freight. A Report to the Office of the Rail Regulator,** (and available from that office), London.

O'Laughlin, K., Cooper, J., Cabocel, E. (1993) **Reconfiguring European Logistics Systems**, prepared by Andersen Consulting and Cranfield School of Management for Council of Logistics Management, USA.

Rosen, S. (1974) Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, **Journal of Political Economy**, Vol. 82, pp.34-55.

Seitz, H. (1993) A Dual Economic Analysis of the Benefits of the Public Road Network, **The Annals of Regional Science**, Vol.27, pp.223-239.

Tweddle, G., Fowkes, A.S. and Nash, C.A. (1995) Impact of the Channel Tunnel: A Survey of Anglo-European Unitised Freight. Results of Phase I Interviews. *Working Paper 443, Institute for Transport Studies*, University of Leeds.

Tweddle, G., Fowkes, A.S. and Nash, C.A. (1996) Impact of the Channel Tunnel: A survey of Anglo-European Unitised Freight. Results of Phase II Interviews. *Working Paper 474, Institute for Transport Studies*, University of Leeds.

Winter, L.M. (1995) The Value of Time of Freight Transport in France: Estimation of Continuously Distributed Values from a Stated Preference Survey, **International Journal of Transport Economics**, Vol.22 n. 2.