European Transport \ Trasporti Europei n. 25-26 (2005): 52-60

Evaluation of quality attributes in the freight transport market. Stated preference experiments in Switzerland

Roman Rudel[1•]

[1] *Istituto di Ricerche Economiche, Lugano, Switzerland*

Abstract

Globalization and European integration increase the claim for better quality in freight transport and logistics services. The paper focuses on the evaluation of different quality attributes of transport services in a significant segment in the Swiss freight market. The paper is based on conjoint analysis, generated by discrete binary choices between alternatives of hypothetical transport services, described by a combination of four attributes articulated on different levels. The estimated results confirm the high importance of punctuality and avoidance of damages. It could also show the statistically significant relation of the declining value of time with increasing distance.

Keywords: Freight transport; Stated preference; Discrete choice model; Value of time; Switzerland.

1. Introduction[1]

In the last twenty years, globalization and European integration have led to a substantial increase of freight transport that was further fuelled by cheaper communication and decreasing transport costs. This process is accompanied by a structural change towards lighter and more voluminous freight goods, generally shipped at higher frequency. New production concepts and spatial production networks have enhanced the significance of logistics. For this reason logistics services are usually outsourced to specialized companies. At the same time new patterns in production and in the distribution process generate demand for high quality transport and logistics services.

• Corresponding author: R. Rudel (roman.rudel@lu.unisi.ch)

[1] The paper presents first results of a research project financed by the Swiss federal road authority, whose support is gratefully acknowledged. The project was carried out by IRE of the University of Southern Switzerland and Rapp Trans AG, a consultancy based in Zurich. We would like to thank Prof. Kay Axhausen (IVT- EHTZ) and the accompanying team of experts for their helpful comments, which have substantially improved the project as well as Prof. Romeo Danielis (University of Trieste) for his "technical help". The usual disclaimer applies.

So far, the empirical transport research on demand behaviour was either focused on mode choice or the time aspect or the value of travel time saving. Compared to passenger transport stated preference analysis in the freight market is still in its infancy as underlined recently by Regan and Garrido (2001). This can be explained to a certain extend by the difficulties to create a significant sample and to deal with the extreme complexity. An interesting overview with national case studies can be found in Danielis (2002). In Switzerland, no representative national analysis on the value of time in freight transport is available, with the exception of one first attempt regarding the transalpine freight market (Maggi, Bolis, 1999). However, besides time, other quality attributes, such as punctuality and avoidance of damages, become more and more important in the context of present logistics services.

The main goal of the research project was to analyse and to monetize the significance of quality attributes in the freight transport market. The evaluation of the key quality attributes of freight transport services is based on a stated-preference analysis. The paper is focused on a specific freight market segment and therefore its results are not representative for the entire Swiss freight market. In spite of this limitation the following results with a monetary valuation of quality attributes represent a first step and input towards the building up of a framework for cost-benefit analysis of new infrastructure investments or other investments to improve the traffic conditions on Swiss roads. A critical analysis of the role and significance of the value of travel time savings in cost-benefit analysis and of the tendency to overestimate the value of time is given by Bergkvist (2001).

In Section 2 we introduce shortly the method of conjoint analysis or stated preference (commonly used as a synonym) and the sampling approach, focussed on a significant market segment, followed by a description of the companies and the typical transport relations, which constitute the reference of the experiments in Section 3. In Section 4 we present the results of the statistical analysis of the empirical data. In the final Section 5 we draw some conclusions.

2. Method and investigated market segment

The research project is based on a standardised interview and a conjoint – or stated preference analysis for hypothetical transport services based on a computer experiment. The experiment consistently refers to a typical transport-relation chosen by the logistics managers. The logistics context of the transport relation was described by four variables, whereas the hypothetical transport services were characterized by four attributes (price, time, punctuality and avoidance of damage) according to the literature. Hence, the experiment was based on the following attributes and attribute levels.

Table 1: Quality attributes and their levels.

Transport service				Logistics context		
Price	Avoidance of damage	Time	Punct-uality	Notice time	Mode	Frequency
-20.0%	98%	-20.0%	98%	Immediately	Truck	Daily
-10.0%	96%	-10.0%	95%	Same day	Rail	Every 2 days
0.0%	94%	0.0%	90%	Next day	combined	Every 4 days
+ 10.0%		+ 10.0%				weekly
+ 20.0%		+ 20.0%				

The four variables at the right hand side of the table, where used during the interview, introducing the experiment, in order to characterize the logistics context of the chosen typical transport relation. Originally, the logistics context was described by four different variables. The fourth variable referred to the possibility to trace and track the shipments. After all experiments it had to be recognised that this variable didn't discriminate the different shippers and therefore could help to improve the model. Meanwhile, the variables to describe the transport service were fully integrated in the experiment. The scale for the different levels for price and time is large compared to real offers. The logistics managers after some explanations accepted the hypothetical character of these values. However, during the preparation of the experiment they stressed, that a similar scale was not accepted for the other due variables. In fact, several of the interviewed logistics managers during the pre-test insisted to consider an even smaller scale, since the values refer to the percentage transport volume of the typical transports relation consigned with these characteristics.

A principle assumption of the research project regards the relation between the transport service and the logistics context. The underlying hypothesis was that logistics managers evaluate the transport services in the context of the logistics context of a specific transport which may vary within the same company. Hence the evaluation of the transport service quality is not necessarily depending on the attributes of the company. For a more sophisticated treatment of interaction see Hensher (2003).

After having described the typical transport relation and its logistics context, the logistics managers were faced with the (binary) choice between two alternative and hypothetical transport services, each being defined by a combination of quality attributes at different levels. By the choice they made the logistics managers expressed their preference for one of the two combinations. The experiments were carried out with the commercial software CBC (Choice-Based Conjoint) by Sawthooth, 2003.

Which of the following alternatives would you choose for the typical transport relation?

Transport price	**Price plus 10%**	**Present price**
Damage	**98% undamaged**	**94% undamaged**
Time	**10% longer**	**Present time**
Punctuality	**present**	**95%**

Fig. 1: Example of a binary choice situation.

The basic assumption of the experiment is that the choice of a transport service alternative is based on the linear addition of preferences for single items (partial preferences). During the experiments these choices were repeated twenty times, as a

rule for two typical transport relations. The collected data base is constituted by 66 valid experiments and 1320 binary choices, available for the statistical analysis.

In the light of the high expenditure for a stated-preference analysis and computer-based experiment in the transport market, the project had to be restricted to a relevant market segment. Thus, 35 logistics managers of median and large companies of the food and wholesale sector finally agreed to join our sample. However, the logistics operators were asked to choose transport services on the supply - and distribution side using different transport modes for the experiment. Neither forwarders nor transport operators were included in the sample, since the evaluation of the quality aspects is meant to reflect the perspective of the "consumer" of transport services.

3. Descriptive results

The focus of the project was the market segment of wholesale and food. The sample is constituted mainly by medium and large companies. More than fifty percent of the investigated companies had more than 250 employees, exceeding by far the medium size of the Swiss firms. Therefore the sample is not representative for the chosen market segment as far as the company size is concerned. The main concern was to include companies with a wide range of transport requirements and a specialized logistics department with high experience (more than 500 shipments per week), a large number of different articles and a high number of suppliers as well as clients. These companies, however, outsource to a considerable degree logistics services. The tendency to outsource logistics services clearly increases with the declining strategic importance of these services as shown in the following table.

Table 2: Outsourced logistics services.

Logistics services	Number of companies in the sample
Electronic data elaboration	3
Inventory control	5
Storage	10
Quality control	3
Packaging	7
Labelling	6
Transport	33

As a consequence of the high degree of outsourcing of the transport services the analysed companies dispose of relatively few own transport means. The following table indicates the type of transport means and the number of companies in the corresponding categories. The first cell, e.g., indicates that 19 companies do not own one single truck and only 3 companies have more than 50 trucks in their company fleet.

Table 3: Own account transport means.

	0	<9	10-49	>50	Total
Trucks	19	5	7	3	34
Semi-trailer	27	6	0	2	35
Small truck < 3.5 tons	25	8	2	1	36
Swap bodies	25	0	0	0	25
Containers	34	1	0	0	35
Railwaggon	34	0	0	0	34

An essential feature of the whole experiment with the logistics managers regards the typical transport relation. In spite of our relatively homogenous sample, compared to other comparable studies, the variance in the typical transport relations is quite impressive. The following table summarises the most important characteristics of these transport relations.

Table 4: Characteristics of the typical transport relations.

	Minimal value	Mean value	Median value	Maximum value
Weight of transport goods in kg	4	9'100	7'250	26'000
Value of transport good pro kg	0.02	24.6	4	300
Transport costs	8.6	869	580	5'500
Transport time	0.5	48	6	672
Value of shipment in CHF	60	106'500	20'000	2'220'400
Distance in km	18	695	189	8'000

This heterogenity in the chosen transport relations constitutes a major difficulty in the interpretation of the results and makes it particularly difficult to draw general conclusions on the basis of the investigated sample. A problem that can hardly be avoided in the analysis of disaggregated demand behaviour in the freight market. (

4. Discrete choice models and results

The value of time and the monetary values of quality attributes of the variables "punctuality" and "avoidance of damage" are based on an econometric analysis of different formulations of the utility function. They are all based on the assumptions of the random utility theory, where the utility of a choice depends on systematic term (measurable influence by the four variables in the experiment) and an error term.

$$U_{ik} = V_{ik} + \varepsilon_{ik}$$

In present experiment situation the dependent variable on the left hand side of the equation represents a binary choice, between one of the two alternatives on the computer screen. The possible value of this variable is either 0 or 1. The linear regression model for the statistical analysis cannot be applied. Therefore it has to be transformed in two steps, in order to fit the binary values of the dependent variable. The econometric analysis is based on the maximum likelihood method (Urban 1998). The data was analysed with the LIMDEP software package version N-logit 3.0.
The mathematical formulation of the underlying model or utility function of the basic model (Model 1) can be expressed as follows:

$$U = \alpha + \beta_P Price + \beta_T Time + \beta_D Damage + \beta_{Pu} Punctuality + \varepsilon$$

Besides the attributes used in the conjoint-analysis, random parameters and a distance related elasticity parameter for the price variable were introduced, into the model and successfully estimated, according to a recent study by König (2004), whereas no

statistically significant relation could be identified between the basic model and the logistics context or characteristics of the companies.

$$U = \beta_{p^*}\left(\frac{Transportdistance}{Mean-transportdistance}\right)^{\varepsilon_{Dist}} * Price + \beta_z Time + \beta_s Damage + \beta_{Pu} Punctuality + \varepsilon$$

Table 5: Model estimations with and without elasticity parameter.

Variables	Unit	Entire sample	
		Binomial-Logit	Elasticity-parameter
Price	%	-3.173	-4.106
(t-ratio)		(15.503)	(-20.6713)
Time	%	-.4894	-0.517
		(-3.620)	(-3.79733)
Avoidance of damage	%	41.402	42.523
		(13.974)	(14.2033)
Punctuality	%	28.580	29.375
		(9.994)	(-10.141)
Elasticity parameter			-0.225
			(5.869)
N		1320	1320
Log L		-573.763	-560.030
Log L (0)		-914.081	-914.954
Rho-square		0.369	0.388

All parameter values are statistically significant and present the correct sign. The introduction of an additional model specification with the elasticity parameter could improve the values the single parameters as well as the overall model fit, expressed by the higher value of the Rho-square and log likelihood. Within the results of single models the parameter values can not be compared directly, because they refer to different scales (Urban, 1993).

The figure below, the elasticity parameter of the price variable contributes to showing up the relation between the value of time and the distance.

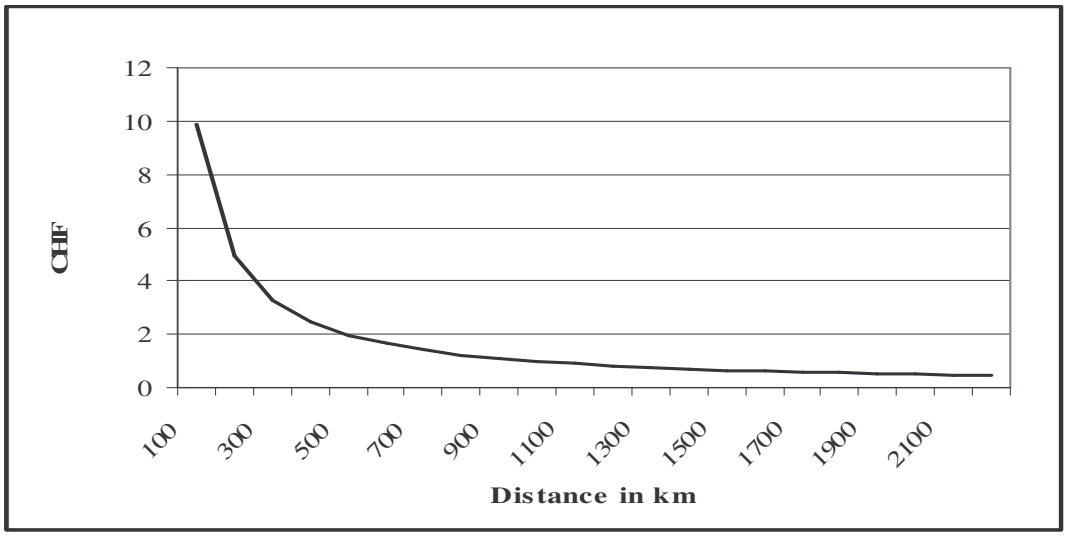

Fig. 2: Calculated relation between the distance and the value of time.

A similar figure emerges for various segments introduced in our sample. It clearly underlines that the value of time sharply decreases with the distance. The segments are based on different criteria such as logistics context, transport mode, transport in the internal, the import and export market, each segment represented by a different mean distance.

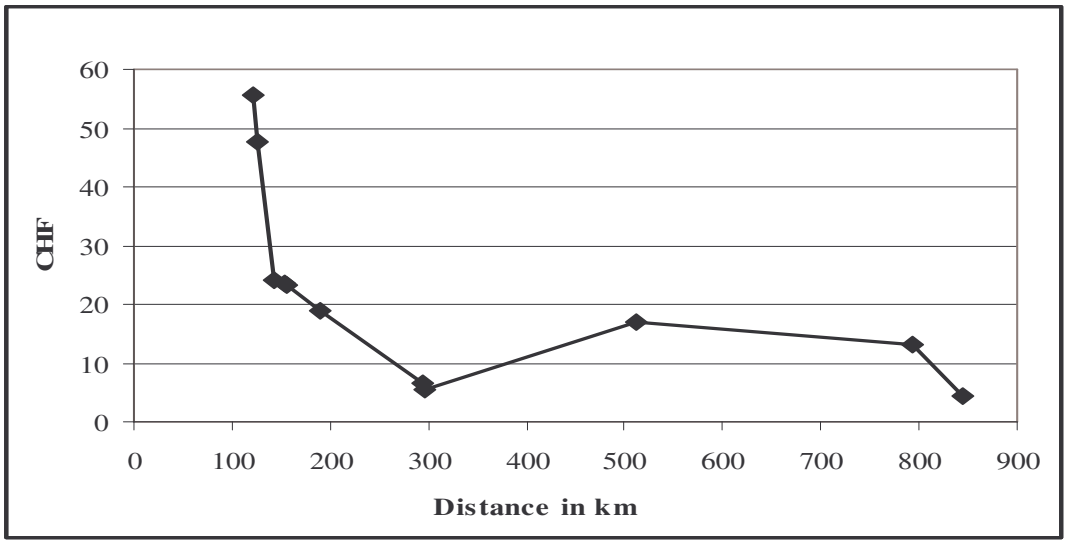

Fig. 3: Value of time for different market segments.

A similar relationship could be identified neither for other quality attributes nor for the value of the freight goods. The monetary values of the three different quality attributes, as used in the SP-experiments, correspond to the declared willingness to pay for an improved quality of transport services for a shipment of 7.25 tons over a distance of 189 km:

Table 6: Monetary value the different service quality aspects.

	Reduction of transport time	Increase of punctuality	Avoidance of damages
Willingness to pay	/ 1 hour	/ 1%	/ 1%
CHF	16.19	48.23	78.01
CHF/Tonne	2.23	6.65	10.76

The estimated value of time must not to be mixed up with the transport operator's costs. The saving of one hour of transport operational costs is worth considerably more than the estimated value of time, which reflects the shipper's perspective and is comparable with the values in international studies. These results cannot be applied to the whole freight transport market for several reasons: in particular, the lack of statistical data, which would bring about a classification of the typical transport relations and help determine to what degree they represent the transport market.

However, the results seem to be in line with the results of similar studies, cited by DeJong (2000), with the exception of Small et al. 1999, a study carried out in the United States. It was not possible to consult the original study and we ignore the precise reference of the study. In any case the indicated values seem to represent an outlier.

Table 7: Selected international studies with value of time estimations.

Authors (Studies)	Year	VOT (in CHF)
Bergkvist/Westin (S)	1998	1.9 - 43.3
Small et al. (USA)	1999	261-400
Bergkvist/Westin (S)	2000	1.5
De Jong et. al. (F)	2001	7.5 – 16.5
DeJong/Rand (NL)	2004	25.3
Mean value in Europe		29.5

Source: DeJong, 2000.

5. Conclusions

The empirical study on the individual demand behaviour of logistics managers and the subsequent model estimation yield interesting results that are new for Switzerland. The study has clearly shown that shippers and their logistics managers evaluate quality attributes such as punctuality and avoidance of damages at least as highly as travel time savings.

An important result refers to the monetary values of the different quality attributes of transport services, which are much higher in the internal market than in the import and export segment, with its clearly longer average distances. The relation between the value of time and distance was confirmed when an elasticity parameter was introduced into the model. This result will have to be taken into account when defining a framework for the cost-benefit analysis of infrastructure investments or other measures for the improvement of road traffic conditions.

The study revealed no statistically significant relations between essential characteristics of the companies and their evaluation of quality attributes. This seems important in so far as the sample refers to a market segment, which is quite homogenous as compared to similar studies. This implies that the differences in the evaluations cannot be traced back to the characteristics of the company but rather stem from differing claims on transport service quality. However, in the scope of this study it is not possible to compare the evaluation of quality attributes among different productive sectors and the study fails to make statements on representative monetary values for the various quality attributes.

References

Bergkvist, E. (2001) *The value of time and forecasting of flows in freight transportation*. ERSA, Zagreb

Bolis, S. and Maggi, R. (2000) *Modelling the transport and logistics choice of a shipper*. Berichte des NFP 41 “Verkehr und Umwelt”, Bericht M8, Bern

Danielis, R. (2002) *Freight Transport Demand and Stated Preference Experiments*. Franco Angeli, Milano

DeJongm G. (2000) “Value of Freight Travel-Time Savings”, In: Hensherm D. and Button, K. (ed) *Handbook of Transport Modelling*. Elsevier

DeJong, G., Gunn, H. and Ben-Akiva, M. (2004) “A meta-model for passenger and freight transport in Europe”, *Transport Policy*11: 329-344

Hensher, H. (2003) “Models of Organisational and agency Choices for Passenger and Freight. Related Travel Choices: Notions of Inter-Activity and Influence”, *Resource Paper* prepared for the 8th IATBR Conference workshop on Models of organisational choices, Luzern

König, A., Axhausen, K. and Abay, G. (2004) *Zeitkostenansätze im Personenverkehr: Hauptstudie*, Forschungsbericht SVI 2001/534, IVT, Rapp Trans AG, Zürich

Louviere, J. (1988) "Conjoint Analysis Modelling of Stated Preferences", *Journal of Transport Economics and Policy*

Maggi, R. and Bolis, S. (1999) *Adaptive Stated Preference Analysis of Shippers' Transport and Logistics Choice*, World Transport Research -Proceedings from the 8th World Conference on Transport Research, (Meersman, H., Van de Voorde, E., Winkelmans, W. eds.), Pergamon, Amsterdam

Orme, B. (2001) *CBC User Manual Version 2*, Sawtooth Software Inc., Sequim, WA

Regan, A. and Garrido, R. (2001) "Modelling Freight Demand and Shipper Behaviour: State of the Art, Future Directions", In: Hensher, D. (eds) *Travel Behaviour Research: The Leading Edge*, Pergamon, Amsterdam

Urban, D. (1993) *Logit – Analyse. Statistische Verfahren zur Analyse von Modellen mit qualitativen Response-Variablen*. Gustav Fischer, Stuttgart