European Transport \ Trasporti Europei n. 25-26 (2003-2004): 9-20

Freight transport demand in the mechanics' sector of Friuli Venezia Giulia: the choice between intermodal and road transport

Jacopo Zotti[1*] and Romeo Danielis[1]

[1]*Department of Economics and Statistics, University of Trieste, Italy*

Abstract

During recent years, freight transport has been experiencing an enormous growth, affecting in particular the road transport. In Italy as well as in most developed countries, this has called for appropriate policies aimed at a modal switch. A notable role in this context could be played by intermodal transport. This paper supplies a new transport attributes' evaluation, estimating the possibility that firms rely on intermodal transport rather than on road transport. Consistently, the transport mode is threaded as a choice attribute. Differently from other studies (see for example Matear and Gray, 1993 and Lu, 2000), the modelling framework introduces attribute cut-offs (Swait, 2001), in order to account for a two-stage decision process. The dataset used for this study is the result of 30 interviews, which have been realised in the Italian region of Friuli Venezia Giulia. Results show that the transport mode does not represent a discriminatory choice variable, while attributes related to the quality level of the service (e.g. damages and losses) are as important as cost attributes.

Keywords: Discrete choice models; Freight transport attributes; Cut-offs.

1. Introduction

The van Miert report dating back to the end of June 2003 represents, after the White Book, an important moment for the transportation politics in the enlarged EU, introducing a new vision of the European transportation system. It replaces the traditional individual mode approach with the concept of a seamless intermodal transportation system which is to be efficient, safe and environmentally sound. In this framework the intermodal transport has to be considered as a possible alternative to currently adopted more road-oriented solutions.

In this background, this paper aims to analyse the position of the freight transport demand with reference to the introduction of politics supporting the intermodal transport. The importance given by the mechanics' companies of the Italian region of Friuli Venezia Giulia to the attributes of the transport service is investigated, giving particular attention to the modal choice.

* Corresponding author: J. Zotti (jacopo.zotti@econ.units.it)

The study is composed by four parts:

- sampling;
- data gathering;
- database construction;
- results' analysis.

2. Sampling

The sample considered has been constructed basing on four criteria, which correspond to the trade-off between disposable resources for this survey and theoretical principles.

The first criterion deals with the industrial system of Friuli Venezia Giulia, which is based on few very relevant sectors (furniture, mechanics, metal mechanics) and a large number of minor sectors. In this context, it has been decided to concentrate the attention on the mechanics' sector.

The second criterion takes into consideration the geographical position of the companies. The selected sample mirrors the settlement density at provincial level and for each company takes into consideration the different accessibility degree to the main regional transport infrastructures.

The third criterion (relating to the company dimension) supposes that larger companies present a more complex and therefore more developed logistics than in smaller companies. For this reasons, medium-large enterprises have been preferred to smaller ones.

The last criterion reveals to be of basic importance for the analysis of companies' position towards intermodal transport and allow selecting only those companies which are using medium-long distance (i.e. above 400-500 km) transport services. At these distances intermodal transport is an option against road transport.

3. Data gathering

The gathered data were collected during an interview and cover the socio-economic features and the preferences about freight transport for each company. Each interview has been recorded on digital support.

3.1 The Phone Pre-Interview

The phone pre-interview was made up by two questions and was used to build the sample. The first of these was aimed at excluding all those companies selling *ex works* or buying *cost insurance and freight* (CIF), which would be therefore trivial for the study. The second question was aimed at asking the interviewee to consider a concrete shipment case study, having particular importance for his/her company. This was called benchmark shipment. According to these two questions the disposability and the possibility to use the intermodal transport was investigated for each company.

3.2 The Preliminary Interview

The first part of the interview, also called preliminary interview, follows the outline represented in table 1. The benchmark shipment, which is important for the company and interesting for the survey, is considered as baseline to define the discrete choice experiment. The interviewee has been asked to define the physical-merceological as well as economic features of the benchmark shipment, making a difference between actually used transport mode (usually road transport) and the hypothetical alternative (intermodal transport). This information allows comparing the revealed with the stated preferences, which were obtained during the hypothetical choice exercises.

Table 1: The preliminary interview

2. Preliminary interview

1. The benchmark shipment

1.1. Description of the usually received/sent shipment (please make an example):

a. value:
b. weight:
c. volume:
d. merceological typology:

1.2. Description of the usual shipment along with the following aspects:

	Actual choice	Perceived alternative
Origin		
Destination		
Cost (door to door)		
Trip time (door to door)		
Delayed arrivals (%)		
Frequency of damages and losses (%)		
Average amount of damage/loss		
Shipment frequency (weekly)		
Flexibility		

1.3. degree of representatives of the benchmark transport:

2. cut-off definition:

[…]

During the second part of the interview, data on interviewee's cut-offs were gathered. The concept of cut-off (see Swait, 2001) is explained by the following consideration: Due to their limited capabilities and resources as information processors, decision makers adopt a two-stage decision process. In the first stage alternatives are screened by a non-compensatory process and in the second one, they are evaluated via a compensatory decision rule (see Manski, 1977). The present article will not concentrate on the cut-off topic and related models, leaving this to Marcucci (the same review). Just some results will be briefly taken into consideration in the following paragraph.

3.3 The Conjoint Analysis Test

The second part of the interview contains the conjoint analysis test, aiming at gathering data on companies' preferences about transport service choice[1]. In order to put the interviewee at ease with the test, a direct qualitative valuation experiment has been introduced. It has been asked to indicate the importance degree of each attribute of the freight transport service, according a scaling of 5 levels (from 1 to 5).

The conjoint analysis test is composed by 15 choice exercises, offering the choice among three transport alternatives, two of which are hypothetical and the third one having the same features of the benchmark transport. Table 2 shows the 7 attributes describing each transport alternative together with all the related levels.

Table 2: Attributes and levels considered in the conjoint analysis test

Attributes	Levels
Mode:	Intermodal Road
Shipment cost:	Current Less than 5% More than 5% Less than 10% More than 10% Less than 15% More than 15%
Time:	Current Less than half day More than half day More than one day More than two days
Time reliability:	100% of shipments are on time 85% of shipments are on time 70% of shipments are on time
Damages and losses	Damages' and losses' probability equal to 0 Damages' and losses' probability equal to 5% Damages' and losses' probability equal to 10% Damages' and losses' probability equal to 20%
Frequency	High Low
Flexibility	High Low

[1] The experiment has been carried out using the ChoiceBasedConjoint (version 2.6) software, produced by Sawtooth Inc.

Basing on the specified attributes and levels, the software produces the required number of choice exercises.

3.4 The In-Depth Interview

Finally the interviewee has been asked some questions which allow a better understanding of the decisional processes of the each company. Questions regard in particular:

- dimension and company geographical structure;
- production sector and position in the supply chain;
- company logistics;
- transport service management;
- possibility and disposability for intermodal transport.

Due to the lack of space, it is not possible to represent the entire outline of the in-depth interview, which can be found in Zotti (2004).

The gathered information allow socio-economical analysis's and a global valuation of each company as well as the sample segmentation, offering the opportunity to study how different company features influence and limit the choice making process.

4. The sample obtained

The sample obtained is composed by 30 companies, the 57% of which have a turnover up to 10 millions euros, the 27% with a turnover between 10 and 25 millions of euros and the remaining 16% with a turnover above 25 millions euros per year. The features of the average benchmark transport are depicted in table 3.

Table 3: The average benchmark shipment

Transport service attributes	*Average figures*
Mode	road (100%)
Distance (km)	1.063
weight (t)	25,18
Cost (door to door) (€)	901,75
Unit price (€/tons-km)	0,40
volume (m^3)	36,29
Value of the goods shipped (€)	36.260
Time (days)	2,98
Delayed arrivals (intermodal)	60,20%
Delayed arrivals (road)	0
Damages' and losses' frequency	1,32%

5. Results

Basing on the large number of data gathered, it is possible to present different results typologies. Some of these will be discussed in this paper while other will be just mentioned. For further details see Zotti (2004).

5.1 The Preliminary Interview

Thanks to the preliminary interview, a number of data have been gathered, which allow to discuss the results reported hereby. As to the revealed preferences, the comparison with the actual transport data has given the opportunity to quantify (see table 4) how intermodal transport is perceived. In each table column, information about the attributes where intermodal transport is considered better, worse or equal to road transport is reported. As can be observed, only under the cost aspect the intermodal transport is perceived better than the correspondent road transport by the majority of the interviewed companies. On the other side, the intermodal transport is considered to be not convenient as to trip time, damages and losses and flexibility.

Table 4: Intermodal transport general perception

	intermodal > road		*intermodal < road*		*intermodal = road*		*total*
cost	16	53%	13	43%	1	3%	30
Time	7	23%	20	66%	3	10%	30
Time reliability	5	17%	6	20%	19	63%	30
Damages and losses	0	0%	18	60%	12	39%	30
Frequency	0	0%	4	13%	26	86%	30
Flexibility	2	7%	20	67%	8	26%	30

The cut-off data processing has allowed calculating the average cut-off for each attribute (table 5). For each attribute, the average cut-off is a border level indicating that every alternative containing a level equal or higher than the cut-off is rejected by the average individual. In particular the cut-off on the intermodal time reliability shows that the average individual do not accept alternatives containing a number of delayed shipments higher than 89,50%.

Table 5: Average cut-off for each attribute

Attribute	*Average cut-off*	*cut-off explanation*
Mode	6,67%	= 2 companies over 30 do not accept intermodal transport
Cost	4,98%	= highest acceptable increase (%)
Time	1	= highest acceptable increase (days)
Intermodal time reliability	89,50%	= highest acceptable delayed shipments (%)
Road time reliability	4,10%	= highest acceptable delayed shipments (%)
Damages and losses	0,38%	= highest acceptable damages' and losses probability

In particular, table 6 present the number of companies which are ready to accept a greater and greater cost increase.

Table 6: Cost cut-off

highest acceptable cost increase	*Number of entreprises*	
Up to 5%	17	57%
5% - 10%	4	13%
10% - 15%	8	27%
15% - 20%	0	0%
Up to 30%	1	3%
TOTALE	*30*	*100%*

5.2 The Multinomial logit Model

The best estimate of the multinomial logit model is presented in table 7.

Table 7: Multinomial logit model (with intermodal time reliability)

	Coefficient	*t-statistic*	*p-value*
MODE	0,24328057	0,605	0,5450
COST	-18,7747126	-9,463	0
TIME	-0,80895414	-4,421	0
INTERMODAL TIME RELIABILITY	0,56995283	1,792	0,0732
DAMAGES AND LOSSES	-56,1692305	-10,220	0
FREQUENCY	0,48439638	1,116	0,2643
FLEXIBILITY	-0,83121859	-1,913	0,0557
COSTANT	0,33897969	1,267	0,2053
Log-likelihood		-152,2240	
Adjusted r-squared	No coefficients	0,67851	
	Constants only	0,60198	

It can be noticed how the model significance is satisfactorily high and how some attributes such as transport cost, damages and losses and trip time have the correct sign and are statistically significant. Flexibility and time reliability have the correct sign but are less significant while frequency and mode are not significant. The result about this last attribute proves that most companies are indifferent to the mode used for the production of the transport service if the quality level of the service is satisfactory. This is an important result if referred to the transport politics. With reference to the time reliability attribute, some considerations will be made in the following paragraph.

The model just presented is the result of a number of estimates of different model specifications: a first model, provided with all the attributes and the two alternative specific constants, and other models, without the non-significant variables. The comparison between these models has allowed excluding the presence of any systematic distortion in the data and has suggested maintaining the full specification with all attributes. Furthermore, the model with only one alternative specific constant, (which is the one relating to the third alternative, the benchmark transport) has been estimated in order to check if there is a negative inertial factor towards the status quo. The results allow rejecting the hypothesis that such a factor exists.

The interpretation of the time reliability attribute has proved something problematic. During the carrying out of the interviews, it has been perceived that the definition of the reliability concept given a-priori (a shipment is on time if it arrives within an hour delay), which we will call intermodal time reliability is not a significant one for the enterprises belonging to the mechanics' sector. For this production sector, the concept of time reliability is less strict, being a shipment considered on time if it arrives within a half day delay (let's call this road reliability). The variable reliability has been therefore revised and a new model has been estimated, which is represented in table 8. The model with this new specification has better statistical qualities and the time reliability variable itself gains in statistical significance.

Table 8: Multinomial logit model (with road time reliability)

	Coefficient	*t-statistic*	*p-value*
MODE	0,25819034	0,635	0,5253
COST	-19,3767711	-9,386	0
TIME	-0,85474372	-4,541	0
ROAD TIME RELIABILITY	4,18124610	3,490	0,0005
DAMAGES AND LOSSES	-57,5910158	-10,301	0
FREQUENCY	0,35980021	0,813	0,4163
FLEXIBILITY	-0,91679317	-2,057	0,0397
COSTANT	-0,57562537	-1,908	0,0564
Log-likelihood		-147,3871	
Adjusted r-squared	No coefficients	0,68873	
	Constants only	0,61462	

5.3 The Mixed Logit Model

The mixed logit model (also called random parameter logit model, see Hensher and Greene 2003, Train 2002) allows representing, by defining the choice set of each individual, the choices of every agent in auto-correlated way. This is the typical tool to manage multiple choice experiments basing on stated preferences regarding more individuals. Since these observations are understandably correlated, the mixed logit model permits to represent the changes between the preferences of the different individuals.

Considering the second version of the multinomial logit model presented in the previous chapter as the starting point for our analysis, the first step lies in understanding for which variable the coefficient is to be considered random. Given the 7 independent variables, a number of estimates showed that two of them (frequency and flexibility) are not to be considered as having random coefficients since these results to be not significant. The coefficients of the other 4 main variables (cost, time, reliability, damages and losses) are all worth to be considered as random. This is represented in table 9.

Table 9: Random Parameter Logit Model (with road time reliability)

	Coefficient	*t-statistic*	*p-value*
Random parameters in utility functions			
COST	-31.0199861	-6.463	0
TIME	-1.64073846	-3.274	.0011
ROAD TIME RELIABILITY	10.6044812	2.845	.0044
DAMAGES AND LOSSES	-108.443868	-5.422	0
Non-random parameters in utility functions			
MODO	0.61639195	0.931	0.3521
FREQUENCY	-0.03130871	-0.047	0.9627
FLEXIBILITY	-2.37330714	-2.816	0.0049
COSTANTE	-1.26233102	-2.590	0.0096
Derived standard deviations of parameter distributions			
COSTO	5.93507477	0.749	0.4536
TIME	1.86996119	2.792	0.0052
ROAD TIME RELIABILITY	9.14118599	2.624	0.0087
DAMAGES AND LOSSES	42.3012980	4.151	0
Log-likelihood		-130.2454	
Adjusted r-squared	No coefficients	0.73299	
	Constants only	0.66928	

The results presented in table 9 are the last stage of a process involving a number of estimates whereby each of the four significant variables of the model was introduced one by one. In doing so, it could be shown that the random coefficient of each considered variable was actually significant and the larger the number of random coefficients the higher the quality of the model.

As to the modal variable, this is not intrinsically significant, as explained above. For this reason the introduction of this variable as a random coefficient variable means a light improvement of the quality of the model, changing the R-squared adjusted from 0.73299 to 0.73477 (no coefficients) and from 0.66928 to 0.67149 (constants only). The mode coefficient remains obviously insignificant.

5.4 The Latent Class Model

The latent class model assumes that the sample considered can be divided into a number of groups, each one having homogeneous preferences within them but different among them. In our case we will apply the structure of the latent class model assuming that the groups are justified by socio-economic differences which are represented by the corresponding socio-economic variables, which were gathered during the in-depth interview.

The results of the model cover the probability values to belong to each class. In addition the model estimates a set of coefficients for each class. There are no tests about the right number of classes. There are however some criteria which are worth to be mentioned. The Akaike criterion (AIC) and the Bayesian information criterion (BIC) are two of them. Both criteria have to be handled with care: according to McLachlan e Peel (2000) the AIC can sometimes overestimate the number of classes while the BIC underestimate it. This holds in particular when the sample is small. Taking all this into consideration, table 10 represents the results of the two just mentioned tests for the case of one class only, of two and three classes. In addition, model quality data of the above estimated random coefficients model are given as comparing term.

A look at the table shows a clear consistence of the two criteria, indicating the most appropriate number of classes equal to 2. The BIC, as underestimating criterion of the number of classes, shows that two classes exist, while a larger number of classes seems not appropriate. The same result is given also by the AIC, which despite its possible overestimation qualities confirms the result given by the BIC.

Table 10: Latent Class Model: The number of classes

n. segments	*Coefficients*	*LL*	*LL0*	*R-squared*	*AIC*	*BIC*
1	8	-158,0712	-494,3755	0,680	332,1	171,7
2	16	-119,9256	-494,3755	0,757	271,9	147,1
3	24	-116,7713	-494,3755	0,764	281,5	157,6
RPL	8	-130,2454	-494,3755	0,737	276,5	143,9
sample size	30					

Taking the model with two classes into proper consideration, table 11 shows the two coefficient sets and the together with the estimated latent class probabilities.

Table 11: Latent Class Model: The number of classes

	Class 1		
	Coefficient	t-statistic	p-value
MODE	-1.06094021	-1.084	0.2781
COST	-22.0875757	-4.108	0
TIME	-2.89520791	-5.868	0
ROAD TIME RELIABILITY	13.2361387	3.918	0.0001
DAMAGES AND LOSSES	-40.6395990	-5.325	0
FREQUENCY	1.28859892	1.098	0.2721
FLEXIBILITY	-0.82775368	-0.697	0.4858
CONSTANT	-0.87189681	-1.307	0.1913
	Class 2		
MODE	0.83779115	1.791	0.0734
COST	-23.5894587	-11.564	0
TIME	-0.43126803	-2.480	0.0131
ROAD TIME RELIABILITY	3.01902847	2.605	0.0092
DAMAGES AND LOSSES	-76.6304182	-11.242	0
FREQUENCY	0.11765649	0.247	0.8051
FLEXIBILITY	-1.63800762	-3.330	0.0009
CONSTANT	-0.59859228	-2.124	0.0336
	Estimated latent class probabilities		
Probability class 1	28,461%	3.231	0.0012
Probability class 2	71,539%	8.122	0
Log-likelihood		-135.5376	
Adjusted r-squared	No coefficients	0.72056	
	Constants only	0.65389	

As we can read from the table, the two classes are clearly defined. From one side there is a class having time constraints. This is represented by the time coefficient (-

2.89520791) and by reliability coefficient (13.2361387) which are both higher than in the other class. On the other side there is a class which is not interested in the time quality aspects of the transport service but rather in the safety aspects. A slower and even less time reliable but safer transport as to damages and losses is preferred. The two classes are however homogeneous from the cost point of view, as can be seen from the two coefficients.

6. Concluding remarks

The results obtained from this study refer to a homogeneous sample of enterprises: they all belong to the same production sector and are all located within the Friuli Venezia Giulia Region. All these features allow us to support the idea that the information obtained from this study are rather robust.

The study is composed by three parts (preliminary interview, conjoint analysis test, in-depth interview). Each one represents a different information source. The quality of the data gathered as well as of the robustness of the conclusions reached are confirmed by the consistency between the different information sources. For example the results emerging from the direct quality valuation show that the two most important attributes are the cost and the damages (on a scale from 1 to 5, the former shows a value of 4,10 and the latter of 4,5). Trip time is also important (3,63). Mode is not important at all (1,86), as indicated also by all the econometric models.

The econometric estimates confirm the good quality of the data and of the interviews generally, as indicated by the estimates of the constants' coefficients. As to the singular attributes of the transport service, the t-test is evidence for the importance given to the cost and to the damages' coefficient. Time reliability and trip time are also important. The value of the coefficients, as evidence of the degree of the importance of a variable, confirms the importance of the cost and damages. Maybe due to the definition of the frequency and flexibility these two variables have not supplied a particular high information level.

Data gathered during this survey supply a broad range of both qualitative and quantitative information which can not be reproduced here. An important field of analysis would be that of segmentation analysis, in order to understand the relationship between the socio-economic characteristics and the preference structure about the attributes of the transport service.

An important part of this research involves however models of particular nature as the random coefficients model and the latent class model. The RPL model, allowing for a more complex covariance design, permits to capture the unobserved heterogeneity which is due to socio-economic but also to more typical taste and constraint aspects. In our case the importance of the unobserved heterogeneity is illustrated by the higher level of the r-squared in the RPL model with reference to the more traditional ML model. On the other side, however, the results emerging from the estimate of the latent class model suggest that the sample can be significantly divided into two classes, which have different tastes and needs. A further task would be the numerical analysis in order to understand which company belongs to which of the two classes.

References

Danielis, R., (Ed.) (2002) *Domanda di trasporto merci e preferenze dichiarate. Freight transport demand and stated preference experiments*. F. Angeli, Milan, Italy.

Hensher, D.A. and Greene, W.H. (2003) "The Mixed Logit model: The state of practice." *Transportation* 30, 133–176.

McLachlan, G. and Peel, D. (2000) *Finite Mixture Models.* John Wiley and Sons, New York.

Train, K. (2002) *Discrete Choice and Simulation.* Cambridge University Press, Cambridge.

Swait, J. (2001) "A Non-compensatory Choice Model Incorporating Attribute Cut-offs." *Transportation Research, Part B: Methodological* 35 (10) 903-28.

Zotti, J. (2004) La Domanda di Trasporto Merci nel Settore Meccanico del Friuli Venezia Giulia: la Scelta fra Trasporto Intermodale e Modalità Stradale. (mimeo). http://www.univ.trieste.it/~nirdses/dises/faculty/Prin2002_15_09_2004.htm