Shippers' preferences for freight transport services: a conjoint analysis experiment for an Italian region

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The paper reports on the preliminary results of a research project whose aim is to evaluate and compare shippers' preferences for freight transport services. An adaptive conjoint analysis is used to estimate the relative importance shippers attribute to transport costs, travel time, risk of late arrival and risk of damage and loss. The availability of utility estimates for each shipment allows comparing preferences across product type, mode used, shipment distance, procurement or distribution flow, firm size, logistics and outsourcing arrangements. The interviews were administered to large and medium size manufacturing firms located in Friuli-Venezia Giulia, a region of the North-East of Italy.

1. Introduction

Firms (shippers) often rely on freight operators (carriers) for freight transport services. A freight transport service is characterised by its attributes, including cost, travel time, reliability, safety, vehicle or mode used, and additional services such as packaging, paperwork, tracking or tracing, logistical services, special financial arrangements and so on[1]. A growing literature is devoted to estimate shippers' preferences for the attributes of freight transport service using basically three methodologies. A first methodology consists in asking shippers to rate each attribute in a predetermined scale of importance (e.g., 1= not important, 2=important, 3=very important) (Matear e Gray, 1993; Lu, 2000). Alternatively, the importance of freight transport service attributes can be estimated using market data (revealed preferences) or data on choices stated in an interview setting (stated preferences)[2]. This paper reports on a study that made use of the latter approach to investigate shippers' preferences for freight transport services in an Italian region, Friuli-Venezia Giulia, located in the North-East of Italy. Stated preference studies for freight transport are not as abundant as for passenger transport. Danielis and Rotaris (1999) and de Jong (2000) survey them and Danielis (2002) collects the most recent ones, mainly concerning Europe. The study presented in this paper is based upon previous works introducing two main differences: (a) it concerns a specific selection of attributes that differs from previous studies and (b) it makes use of a software package (ACA v. 4.0) which, to our knowledge, has never applied in freight transport research[3].

The list of attributes includes cost, travel time, risk of late arrival and risk of loss and damage and the technical and theoretical reason for such a choice will be discussed in Section 2. The ACA v. 4.0 software, where ACA stands for Adaptive Conjoint Analysis, is one of the many software packages developed by Sawtooth Software Inc. for marketing research. It is characterised by the following features which are particularly suitable given the aim of our study: (a) it is adaptive, (b) it provides the individual utility estimates (one for each interview) of each attribute level, (c) it keeps track of respondent choices among hypothetical options presented within the interview, allowing to perform standard econometric analysis of stated choices and estimate attribute parameters. Using an adaptive methodology[4] means that the questions are customised on previous answers so that the interviews are more interesting for the respondent and more time-efficient. The availability of individual utility estimates allows to perform correlation and segmentation analysis of the relationship between stated preferences and shipment's and firm's characteristics, such as procurement or distribution shipment, shipment distance, mode used, and firm size, logistics organisation, and outsourcing arrangements[5].

Section 4 illustrates the characteristics of the firms interviewed, the main results obtained at individual level, and the econometric estimates. Section 5 draws some conclusions on the pros and cons of the methodology and summarises the main findings.

2. The theoretical model

The selection of attributes and the definition of their level[6] is a crucial part of a stated preference experiment. Bolis & Maggi (2002) and Meier and Bergman (2002) investigated a large set of attributes including cost, transit time, reliability, frequency, flexibility and mode. We chosed to restrict the attributes to cost, transit time, risk of late arrival, risk of loss and damage[7]. Our choice of these attributes is based on: (a) their importance for shippers, as it appears from previous studies (see Danielis e Rotaris, 1999; and Danielis, 2002), (b) a technical constraint and (c) a theoretical reason. From a technical point of view, a full profile ACA experiment presenting more than 4 attributes could be too difficult be performed by the respondents (see ACA manual available in the Sawtooth web-site). The theoretical reason, instead, is related to what we will refer to as the *abstract mode inventory model*, developed, among others, by Baumol and Vinod (1970). Consider the following:

Y = total amount transported per year (quantity demanded annually)
r = shipping cost per unit (including freight rate, insurance, etc.)
t = average time required to complete a shipment (door-to-

door time in years),

s = average time between shipments in years (e.g., s = 1/12 for monthly shipments)

u = carrying cost in transit per unit per year (interest plus deterioration)

w = warehouse carrying cost per unit per year

a = cost of ordering and processing per shipment

i = average inventory level

d = fraction of shipment lost or damaged

p = average price of product shipped

$\underline{t}$ = protected time (number of days-supply which have to be kept at destination to prevent from running out of stock in case of late shipments, see Sheffi et al., 1988)

The total logistics costs (LC) can be represented by the following expression:
LC = direct shipping cost + in-transit carrying cost + ordering cost + recipient's inventory carrying cost + safety stock cost + loss and damage cost (1)
Where:

- direct shipping cost per unit = (cost per unit) x (quantity shipped) = rY;
- total in-transit carrying cost = (cost per unit of time) x (transit time) x (amount shipped) = utY;
- ordering cost = (cost per shipment) x (number of shipments) = a/s;
- recipients' inventory carrying cost = (warehouse carrying cost per unit per year) x (average inventory level) = wi = wsY/2;
- safety stock cost[8] = (warehouse carrying cost per unit per year) x (protected time) = w$\underline{t}$;
- loss and damage cost = (fraction of shipment lost or damaged) x (average price of product shipped) x (total amount transported per year) = dpY.

Therefore

$$LC(s) = rY + utY + \frac{\alpha}{s} ws \frac{Y}{2} + w\underline{t} + dpY \qquad (2)$$

The parameters a, w, p and Y are product- and firm- specific, while r, t, $\underline{t}$, and d are independent attributes or characteristics which define a transport service. The shipper determines s in order to minimise total logistics costs. When two options (abstract modes) are specified in terms of r, t, $\underline{t}$, d, the shipper computes the optimal shipment size and the logistics costs associated which each option, then he selects the option (abstract mode) entailing the lowest total logistics cost. The choice of the transport mode, decided by the shipper or by the carrier, depends jointly on attributes and on shipment size (see Abdelwahab, 1998).
Because some factors influencing the shipper choices are not measurable (e.g., attitude toward some attributes, risk aversion, cognition fatigue and so on) or measured (attributes erroneously considered unimportant by the analyst), the link between stated choice and attributes is modelled as a Random Utility Model, which is based on the assumption that the chosen option maximises the respondent's utility. The indirect utility function U_{jq} that is perceived by the q individual for the j option consists of a deterministic (V_{jq}) and a random (ε_{jq}) component

$$U_{jq} = V_{jq} + \varepsilon_{jq} \qquad (3)$$

Assuming that the random component has zero mean and that the deterministic component is linear and additive in the variables r, t, $\underline{t}$, and d, (V_{jq}) can be expressed as follows

$$V_{jq} = \beta_{j1} r + \beta_{j2} t + \beta_{j3} \underline{t} + \beta_{j4} d \qquad (4)$$

According to the random utility theory the q individual chooses the alternative A_j if and only if:

$$U_{jq} \geq U_{iq} \;, \forall\; A_i \lfloor A \qquad (5)$$

or equivalently if:

$$V_{jq} - V_{iq} \geq \varepsilon_{jq} - \varepsilon_{iq} \qquad (6)$$

so that the probability that the q individual chooses the A_j alternative over the A set can be represented by the following expression:

$$P(A_j \mid r, t, \underline{t}, d, A) = P(\varepsilon_{jq} - \varepsilon_{iq} \leq V_{jq} - V_{iq}) \qquad (7)$$

The β_{jk} coefficients of regression (4) can be estimated using a Logit or a Probit model depending on the hypothesis formulated for the characteristics of the probability distribution of the random component.

3. Methodology[9]

The interviews were carried out with a laptop computer equipped with two software packages called Ci3, a Windows-based software for writing and administering computer-aided questionnaires, and ACA v.4 (Adaptive Conjoint Analysis), both produced by Sawtooth Software Inc. Each interview was made up of two parts:

- during the first part basic information about the firm were collected and, most importantly, the characteristics of the typical input and output shipments of the firm were identified; the Ci3 software helped organising questions and recording answers;
- bearing in mind the typical shipments, managers were then asked to answer the questions generated by the ACA software.

The ACA experiment was performed, separately, both for input procurements and for output shipments. Generally each interview lasted less than an hour. Table 1 presents details on the type of questions asked with the Ci3 software.

Basic Information
Which is the size of the firm in term of revenues and employees?
How many production and distribution plants are there and where are they located?
What are the main and secondary productions carried out?
Information about relationship with customer and sellers
Where are buyer and seller located?
What is type of contract is used (FOB, CIF, other)
Information on production organisation
How would you describe the firm's production organisation?
How is inventory managed?
Information on outsourcing of logistics and transport
Which activities are outsourced and with which contractual arrangement?
Information on typical shipment (for inputs and for outputs)
Which is the origin/destination?
Which is the average travel time?
Which is the average volume/weight?
Which is the average unit value?
What is the good kind?
Is special package needed?
What is the transport cost?
What is the transport mode?

Tab. 1: Questions asked in the first part of each interview

The initial questions aim at collecting basic information about the firm, in order to perform in the segmentation analysis of the estimates, and at defining, both in the managers mind and for statistical purposes, the typical input and output flows.
As already mentioned, an important characteristic of ACA software is that it estimates the utility associated with each level of each attribute, as opposed to the estimate of the attribute utility as a whole provided by other software packages, such as LASP (developed at ITS-Leeds) or MINT (developed by The Hague Consulting Group[10]. This characteristic had to be conjugated with two other important requirements: (a) the need, in order for the hypothetical scenario proposed by ACA to be understood by the respondent, to customise attribute levels, and (b) the need, in order to compare preferences across respondents, to keep the specification of the attribute levels constant across interviews. In order to fulfil both requirements we used the attribute levels reported in Table 2. As the base case scenario we considered the following: transport cost equal to the current cost, travel time equal to current time, zero risk of late arrivals and zero risk of damage and loss. It should also be noticed that time attributes are expressed in absolute terms, while transport cost and risk of damage and loss are expressed in percentage terms in order to relate the attribute level to the actual transport cost and to the value of the typical shipment of the firm. In the first part of the interviews respondents were asked to describe the origin, the destination, the transport cost and the travel time characterising the typical freight flow. During the second part of the interview the respondents were asked to answer to the ACA questions referring to the typical flows characteristics declared before and reproduced, for convenience matters, in a paper sheet.

Attribute # 1 **Cost**	Attribute # 2 **Travel time**	Attribute # 3 **Risk of late arrival**	Attribute # 4 **Risk of damage and loss**
10 % cheaper than the current cost	Equal to the current travel time	Zero risk	Zero risk
5 % cheaper than the current cost	1 day longer than the current travel time	Risk of a ½-day late arrival	Risk of damage and loss equal to 5% of the value shipped
Equal to the current cost	3 days longer than the current travel time	Risk of a 1-day late arrival	Risk of damage and loss equal to 10% of the value shipped
5 % more expensive than the current cost	5 days longer than the current travel time	Risk of a 3-day late arrival	
10 % more expensive than the current cost			

Tab. 2: Attributes and levels used in the ACA experiment

Given the attribute levels defined in Table 2, an hypothetical profile looks like the one presented in Table 3.

Cost	Travel time	Risk of late arrival	Risk of damage and loss
10 % cheaper than the current cost	5 days longer than the current travel time	Risk of a 3-day late arrival	Risk of damage and loss equal to 5% of the value shipped

Tab. 3: Specification of a transport option (full profile)

Given the heterogeneity of typical flows, to ensure realism to the hypothetical scenarios we set up the ACA software allowing the interviewee to define the attribute levels to be considered acceptable and the one to be consider not acceptable under any circumstances. Such a procedure is illustrated in Fig. 1. This would exclude the use of dominated profiles during the interview (e.g., the inclusion of a 5 day-delay in a 1-day shipment)[11]. While such a choice enhances realism and credibility of scenarios, it caused negative effects in terms of comparability of estimates across firms.

Type the number of the characteristic that you could not accept under any condition

1 equal to the current travel time
2 1 more day than the current travel time
3 3 more days than the current travel time
4 5 more days than the current travel time

Fig. 1: Elimination of unacceptable levels

The most important part of the ACA questionnaire is the choice section, called Graded Paired Comparison section. During this phase the ACA software presents two options as illustrated in Fig. 3. The options can be described in a full profile, or a partial profile manner, depending on the number of attributes used to define them. We decided to set up the program as to describe the options through all the attributes all the times (full profiles). The respondent is asked to compare two by two the options, and to express their preferences using a 9-point scale (1 representing a maximum preference for the option on the left, 9 a maximum preference for the option on the right, and 5 indifference between the two profiles).
The ACA estimation procedure is described in detail in the software manual and in the presentation papers

(www.sawtoothsoftware.com). First of all, respondents rate or rank by importance each attribute level, than they declare the importance perceived for each attribute, as shown in Fig. 2.

If Two Services you were considering were both acceptable except for the SINGLE DIFFERENCE shown below, how important would THAT DIFFERENCE be?

A: Risk of loss and damage equal to 0	B: Risk of loss and damage equal to 10%

4 = Extremely important (I could almost never accept B)
3 = Very important (but it would have to be outstanding in other ways)
2 = Somewhat important (but I would not base my decision on this)
1 = Not important at all

Fig. 2: Importance of Attribute Differences

These values are then re-scaled, so that:

- for each attribute the range of utility values is proportional to stated importance, and attribute importance differ by at most a factor of 4;
- within each attribute the values have a mean of zero, and differences between values are proportional to differences in desirability ratings or rank orders of preference.

These values are the *priors* (y and b_1) that are updated after each graded paired-comparison response (Fig. 3) via a quasi OLS estimating procedure.

Which transport service would you prefer?

10% more expensive than the current cost	5% cheaper than the current cost
Zero risk of late arrival	Risk of a 1-day late arrival
Zero risk of damage and loss	Risk of damage and loss equal to 10%
1 day longer than the current time	3 days longer than the current time

Strongly Prefer Left				Indifferent				Strongly Prefer Right
1	2	3	4	5	6	7	8	9

Fig. 3: Graded paired-comparison

The quasi OLS estimating procedure can be described as follows. Let X be a matrix of predictor variables with a row for each of n observations and a column for each variable; y be a vector of responses for the first n observations (for the first iteration it would be the priors estimated during the first part of the interview); z' be a row vector of predictor values for a new observation, appended as a row to X (that is a row with the attribute levels used during the Graded Paired Comparisons part of the test); and r be a response for the new choice exercise. For the first observation the estimating procedure can be represented by the regression equation:

$$X_{b1} \sim y \qquad (8)$$

where $$b_1 = (X' X)^{-1} (X'y) \qquad (9)$$

while for the following observations the estimating model would be

$$\begin{bmatrix} X \\ z' \end{bmatrix} b_{n+1} \sim \begin{bmatrix} y \\ r \end{bmatrix} \qquad (10)$$

where

$$b_{n+1} \sim = (X' X + z' z)^{-1} (X'y + zr) \qquad (11)$$

Finally, utilities are calibrated with the information obtained trough the calibration concepts exercises (Fig. 4).

HOW LIKELY WOULD YOU BUY THIS TRANSPORT SERVICE?
Answer by typing a number from the scale on the left.

100% Very Likely	
90%	10% more expensive than the current cost
80%	Risk of a 1-day late arrival
70%	Risk of damage and loss equal to 10%
60%	3-days longer than the current time
50%	
40%	
30%	
20%	
10%	
0% Not at all Likely	

Fig. 4: Calibrating concepts exercises

The previously described procedure provides individual estimates of each attribute level. Since the software records all steps and choices made by the respondent, it is also possible to use information on choices and ratings to apply LOGIT and PROBIT estimation models obtaining the standard econometric estimates of attribute parameters. We tested the application of the LOGIT model making use of data on choices (excluding the indifference answers) and of the ORDINAL PROBIT model making use of information on preference intensities (on the 1 to 9 scale).

4. Results

As just explained, the ACA software allows two type of results:

- individual estimates of utility levels which can be further studied by segmentation analysis, and
- econometric estimates of attribute importance.

It should be noted that the results presented in this paper are preliminary since there are more interviews to be collected.

The sample

The sample consists of 42 manufacturing firms that are specialised in a variety of products and are localised in Friuli Venezia Giulia, a region in the North-East of Italy on the border with Austria and Slovenia. The transport and logistics managers were interviewed. For what concerns the firms' dimensions: 22 firms employ between 100 and 500 people; 7 firms employ more than 500 employees; and the remaining employ less than 100 people. All firms buy transport services from third-party providers, 3 firms outsource transport and inventory, and 3 firms outsource transport, inventory and packaging. When asked to define how they organise their input and output flows, managers responded as reported in Table 4.

	Inputs	Output
Inventory-to-demand	28	15
Inventory-to-order	7	5
Just-in-time	7	22

Tab. 4: Type of inventory policy

Just-in-time principles are adopted in half of the firms for outflows management, but only in 7 firms for inflows management. Analysis of data on the typical shipment, as identified by managers, provides the following information:

- out of 84 shipments, 7 are within the region, 47 are within the rest of Italy, 19 are with European countries and 11 with non-European countries;
- 68 shipments are made by road-only, the rest is made by other modes or combined modes (2 by rail, 2 by sea, 2 by air, 3 by road and rail, and 7 by road and sea)
- in 57 out of 84 cases, manager declare to use mainly CIF transport arrangements, in 21 they use mainly FOB arrangements. The rest use both arrangements in equal proportions.

Individual estimates

First of all, let us look at the choice-set definition. As mentioned, a decision was made to allow managers to exclude, at the beginning of each ACA experiment, the attribute levels judged unacceptable. This decision was motivated by the need not exclude dominated profiles within the choice sets. Analysis of the number of times a level has been judged unacceptable (Table 5) provides information on the realistic range of definition of each attribute.

Attributes and levels	Input flows	Output flows	Total
Cost			
10 % less	0	3	3
5 % less	0	0	0
Equal	0	0	0
5 % more	10	13	23
10 % more	18	28	46
Travel time			
Equal	0	0	0
1 more day	1	0	1
3 more days	19	33	52
5 more days	22	33	55
Risk of late arrival			
Zero risk	0	0	0
Risk of a ½-day	0	0	0
Risk of a 1-day	13	16	29
Risk of a 3-day	22	34	56
Risk of damage and loss			
Zero risk	0	0	0
Risk of 5%	1	2	3
Risk of 10%	21	30	51

Tab. 5: Number of times a level has been judged unacceptable over 62 shipments

Considering totals, a 10% increase in transport cost is considered unacceptable in 46 out of 62 cases, a risk of 3 days dilate is unacceptable in 56 cases, 3 days or more of travel time is also viewed as highly unacceptable as is a risk of 10% damage or loss. Output shipments appear to have a narrower definition area than input shipments.

Though allowing managers to exclude unacceptable levels improves the significance of the choice experiments, it proved to generate undesired side effects when we tried to aggregate results. In fact, since respondents define their individual choice set, individual utilities estimates are not homogeneous anymore. The software distributes 400 utility points among attributes levels, but the number of attribute levels might differ among firms (because respondents excluded some level), so individual utilities can not be compared. Forcing this logical constraint we present anyhow aggregate results obtained through a simple average (Table 6). Because of the logical inconsistency just mentioned, results for often-excluded attribute levels have little value. Fortunately, there remains a narrower level set that could be used, as below discussed.

Attribute and levels	Average Utility (absolute value)	Average Utility (difference)
Cost		
10 % less	73,69	48,86
5 % less	50,31	25,47
Equal	24,83	0,00
5 % more	10,28	-14,55
10 % more	2,56	-22,28
Travel time		
Equal	62,08	0,00
1 day more	6,27	-55,82
3 days more	4,51	-57,57
5 days more	0,02	-62,06
Risk of late arrival		
Zero risk	55,47	0,00
Risk of a ½-day	16,78	-38,69
Risk of a 1-day	3,77	-51,70
Risk of a 3-day	1,05	-54,42
Risk of damage and loss		
Zero risk	100,89	0,00
Risk of 5%	3,15	-97,75
Risk of 10%	2,17	-98,73

Tab. 6: Average utility by attribute level

Table 6 is to be read as follows. The first column present average utility values for each attribute level for the entire sample. The second columns presents the difference among the utility associated to each level minus the utility of the base level (current transport cost, current travel time, no risk of late arrival, no risk of damage or loss). In order to overcome the impossibility of aggregating all data due to the "unacceptable" distortion, we performed the rest of the analysis considering only those levels that contained fewer or no unacceptable levels, i.e. which were considered in all or most of all the attributes definition ranges. We estimated a substitution index defined as:

$$SI_{XC} = -\frac{\Delta UX}{\Delta UC}$$

where ΔUX is the utility change caused either by a 1-day increase in travel time, or by a ½-day increase in the risk of late arrivals, or by a 5% damage and loss risk (attribute levels almost generally considered acceptable), while ΔUC is the utility change caused a 5% transport cost discount. Consequently:

• SI_{TC} is how many times a 5% freight cost discount should be applied in order to compensate for a 1-day increase in travel time;

• SI_{PC} is how many times a 5% freight cost discount should be applied in order to compensate for a ½-day increase in the risk of late arrivals;

• SI_{DC} is how many times a 5% freight cost discount should be applied in order to compensate for a 5% damage and loss risk[12].

With these definitions and caveats in mind, let us review the results illustrated in Table 7.

Substitution index type	Average	Standard deviation	Monetary value in Euros
SITC 1-day more travel time	2,13	1,64	7,3a
SIPC 1/2-day risk of late arrival	1,57	1,53	10,7b
SIDC 5% risk of damage and loss	3,67	3,14	0,5c

a = value in Euros of one more hour of travel time
b = value in Euros of the risk of a one hour delay
c = value in Euros of a 5% risk of damage and loss for a one thousand Euros shipment

Tab. 7: Average substitution indices

The result for the average value of freight travel time is within the range (on the low side) of the ones reported by de Jong (2000). The result for the risk of late arrival denote a high aversion to delays: an hour of unexpected delay is valued 47% more than an hour of expected travel time. The results should be interpreted cautiously because we did not specify explicitly the exact amount of the risk (e.g., 90% or 50%). Hence, our estimates are to be interpreted as generic aversions to risk of loss and damage and to late arrivals and not as estimates of the value of risk reduction[13].

Thanks to the availability of the utilities estimates and of the substitution indices calculated at the firm level, we could make comparisons among firms' preferences for different production sectors. Anyway, since shipments are not homogenous with regard to travel times and to the value of the transported goods, the results reflect those heterogeneity too.

Tables 8 and 9 present results at a sector level for inflows, and for outflows. Sectors with low transit time, reliability and damage and loss substitution indices will be termed cost sensitive, whereas sectors with high transit time, reliability and damage and loss substitution indices will be termed quality sensitive. The others will be called intermediate.

For what concerns inflow shipments, chemical, machinery and mechanical products, metal products and commerce sectors appear to be quality sensitive. On the contrary, paper and paper products, food and beverages, electrical equipment, computers and electronics seem more cost sensitive.

Travel time substitution index	Risk of late arrival substitution index	Risk of damage and loss substitution index
Chemicals 5,9	Chemicals 3,8	Chemicals 7,8
Machinery and mechanical products 3,6	Machinery and mechanical products 2,5	Machinery and mechanical products 5,4
Metal products 3,1	Furniture 2,1	Metal products 5,2
Furniture 1,7	Metal products 2,0	Construction 4,9
Electric equipment 1,5	Construction 1,4	Food and beverages 3,6
Food and beverages 1,2	Computers and electronics 1,0	Furniture 3,5
Construction 1,1	Electric equipment 0,9	Computers and electronics 2,3
Computers and electronics 0,3	Food and beverages 0,8	Electric equipment 1,8
Paper and paper products 0,01	Paper and paper products 0,01	Paper and paper products 0,05

Tab. 8: Substitution indices by attribute and sector for output flows

Travel time substitution index	Risk of late arrival substitution index	Risk of damage and loss substitution index
Food and beverages 4,9	Computers and electronics 3,3	Computers and electronics 7,4
Computers and electronics 4,6	Food and beverages 3,3	Machinery and mechanical products 5,7
Plastic and rubber products 4,0	Plastic and rubber products 2,8	Food and beverages 5,5
Construction 3,3	Metal products 2,1	Plastic and rubber products 5,2
Paper and paper products 3,0	Construction 1,9	Furniture 5,1
Machinery and mechanical products 2,9	Machinery and mechanical products 1,6	Construction 5,0
Chemicals 2,0	Commerce 1,5	Paper and paper products 3,8
Commerce 1,7	Chemicals 1,2	Chemicals 2,4
Minerals extraction 1,5	Furniture 1,1	Metal products 2,2
Furniture 1,5	Paper and paper products 1,0	Commerce 1,9
Metal products 1,1	Minerals extraction 0,8	Electric equipment 1,8
Electric equipment 1,0	Textile 0,7	Textile 1,7
Wood 0,3	Electric equipment 0,4	Minerals extraction 1,0
Iron and steel 0,3	Wood 0,3	Iron and steel 0,9
Textile 0,2	Iron and steel 0,3	Wood 0,2

Tab. 9: Substitution indices by attribute and sector for input flows

As for outflow shipments, food and beverages, computers and electronics, plastic and rubber products and machinery and mechanical products sectors are quality sensitive, while textile, metal products and wood are cost sensitive.

Because of the small size of the sample, sectorial estimates are case-specific and have a low degree of representativeness, but it should be notice that, contrary to Bolis and Maggi (2002) and similarly to Maier and Bergman (2002), we found a high variability within sectors.

Having tested several segmentation techniques, we report in Table 10 an analysis on the average substitution indices by type of shipments and firm's characteristics and a t-test of the differences in the means.

It seams that for what concerns:

• *Input vs. output flows*: all output substitution indices are larger than input substitution indices. Time substitution indices are statistically significantly different. A possible explanation is that customer satisfaction prevails on internal production logistics concerns.

• *Road-only vs. other-than-road-only shipments* (e.g. road and rail): average time and reliability substitution indices are higher for shipments that made use of road transportation only. The absolute difference among mean values is considerable (one point), though the t-test of difference in means shows a week statistical significance. As regards to the safety substitution index, there is no significant difference among the averages. The result confirms that the road mode has mainly a time-related advantage over other modes.

• *Less than 3-day door-to-door travel time vs. 3-days or more door-to-door travel time*: for shipments which take a longer time firms appear to be more concern with safety and less with reliability and travel time.

• *Less than 500 employee vs. more than 500 employees*: larger firms have small time reliability and (statistically significant) safety substitution indices, that is, the freight cost attribute is more important than the quality attributes. A possible explanation is that larger firms have higher bargaining power that allows them to impose high quality standards to their third-party providers.

• *Other than JIT input procurements vs. JIT input procurements*: firms which have organised there input procurements on JIT principles are definitely more sensitive to the reliability attribute (with a 0,12 p-value) than firms who buy on order or on demand. They are also slightly more sensitive to the safety attribute, whereas there is no difference as regards to the door-to-door travel time.

• *Other than JIT output shipments vs. JIT output shipments.* Similarly to JIT procurements, firms that organised their output shipments on JIT principles are more sensitive to the reliability attribute, but the absolute amount and the statistical significance is much reduced. JIT firms appear also to be slightly more sensitive to the speed of the shipment. There is no difference with regard to the safety attribute.

• *Outsourcing transportation only vs. Outsourcing transportation and inventory*: Firms that outsourced inventory as well as transportation appear statistically significantly less concern with quality attributes and more with the cost attribute. This might mean that global outsourcing takes place when quality matters are of less importance to the firm production process.

	Input flows	Output flows	p-value*	t-stat.
SI_{TC}	1,66	2,89	0,10	1,67
SI_{PC}	1,72	2,01	0,65	0,45
SI_{DC}	3,68	4,27	0,49	0,70
	Road only	**Not road only**	**p-value***	**t-stat.**
SI_{TC}	2,67	1,64	0,24	1,18
SI_{PC}	2,05	1,06	0,16	1,41
SI_{DC}	4,05	4,43	0,70	0,39
	Less than 3-day door-to-door travel time	**3-days or more door-to-door travel time**	**p-value***	**t-stat.**
SI_{TC}	2,69	2,03	0,36	0,93
SI_{PC}	2,09	1,37	0,22	1,25
SI_{DC}	3,83	4,84	0,20	1,28
	Less than 500 employees	**More than 500 employees**	**p-value***	**t-stat.**
SI_{TC}	2,58	2,16	0,62	0,50
SI_{PC}	1,94	1,69	0,71	0,37
SI_{DC}	4,40	2,81	0,09	1,75
	Other than JIT input procurements	**JIT input procurements**	**p-value***	**t-stat.**
SI_{TC}	2,50	2,53	0,96	0,05
SI_{PC}	1,70	2,75	0,12	1,57
SI_{DC}	4,01	4,57	0,55	0,60
	Other than JIT output shipments	**JIT output shipments**	**p-value***	**t-stat.**
SI_{TC}	2,36	2,65	0,65	0,45
SI_{PC}	1,71	2,09	0,48	0,72
SI_{DC}	4,18	4,04	0,84	0,20
	Outsourcing transportation only	**Outsourcing transportation and inventory**	**p-value***	**t-stat.**
SI_{TC}	2,49	0,75	0,20	1,30
SI_{PC}	1,87	0,64	0,25	1,15
SI_{DC}	4,04	1,75	0,12	1,59

* A p-value is the probability of observing a given sample results, or one more extreme, assuming that H0 is true (H0: m1-m2=0)

Table 10: Average substitution indices and t-test of the differences in the means (by flow direction, mode, transit time, firm dimension, logistic organisation and outsourcing level)

Econometric estimates

Using the answers collected during the Grated Paired Comparison phase of the ACA test it is possible to estimate a LOGIT and a PROBIT model (choice data), or an ORDINAL LOGIT and ORDINAL PROBIT model (rating data). The main advantage of these estimates over the ACA utility ones is that they give information on the statistical significance of the attribute parameters. The only disadvantage is that it statistical estimates are available over the sample or specific sub-samples, but not at the individual level14.

We tried to estimate both the LOGIT model and the ORDINAL PROBIT model with the ACA data, expressing attribute levels both in percentage and in absolute terms, but we did not get satisfactory results. The coefficients' signs, except from the risk of damage and loss attribute, are different to what we expected, and most coefficients are not significant. We came to the conclusion that this is due to two factors: the heterogeneity of freight flows, which requires larger samples to bring to statistically significant estimates, and, above all, a lexicographic bias in the respondents' answers. As a matter of fact through the analysis of the respondents' choices we realized that the risk of damage and loss attribute "dominated" the others, obscuring the latter's effect on the stated choices. We believe that such a distortion was due to our decision of presenting the choice options as full profiles, instead then as partial profiles. To test this hypothesis we administered some interview adopting a partial profile design (using two attributes at the time). The results obtain for this small sample are presented in Table 16.

Coefficients	Input and output shipments
Observation N.	107
R^2 Adj no coeff.	0,19
Transport cost	-3,79
p-value	0,21
Travel time	-0,30
p-value	0,07
Risk of late arrival	-1,11
p-value	0,00
Risk of damage and loss	-20,75
p-value	0,00

Tab. 11: Estimates for partial profile data

The coefficients have the expected sign and the statistical significance is satisfactory. The risk of damage and loss is highly significant, confirming the results obtained by the ACA estimating procedure.

Conclusion and caveats

In this research project we tested the use of the ACA software to evaluate shippers preferences. The possibility of using an adaptive methodology, which allowed to obtain individual estimates of attribute levels, seemed very interesting for the prospects of analysing the relationship between preferences and product type, trip length, mode used, input and output flows, firm size and logistics and outsourcing arrangements.

Since the ACA software is set up to provide an estimate of attribute levels, these have to be pre-specified and have to be kept constant for all interviews. Due to the heterogeneity of freight shipments in terms of trip cost, trip length and to the value of the good transport, such a requirement proved difficult to be successfully fulfilled. The solution we adopted (specifying levels in terms of variation from the firm's actual level and allowing to exclude unacceptable levels) proved sufficient to allow meaningful hypothetical options in the choice section of the interview, but posed heavy constraints in the comparability of individual estimates of attribute levels across firms. This forced to recalculate results in terms of substitution indices between time, reliability or safety and transport costs. Nonetheless, the analysis of the estimated substitution indices provides meaningful and interesting results:

- Firms ascribe the greatest importance to the minimisation of the risk of the transported good loss and damage. In the full profile experiment, the safety attribute received high utility levels and determined lexicographically the choice between transport options. The lexicographic bias can be corrected by adopting a partial profile design.
- Reliability is an important requirement in choosing among transportation services. Its importance is very likely greater than travel time. Bolis and Maggi (2002, p. 220) and Maier and Bergman (2002, p. 271) reach the same conclusion.
- Contrary to Bolis and Maggi (2002, p. 220) and similarly Maier and Bergman (2002, p. 271)15, our estimates show that firms' preferences vary considerably across sectors.

Splitting the sample in two parts - according to mode used, shipment distance, procurement or distribution flow, firm size, logistics and outsourcing arrangements – it is found that the t-test of differences in means signals a statistically sufficient (a p-value of less than 20%) difference among these categories;

- firms value of travel time is higher for distribution than for procurement;
- he reliability value is higher for shipments which take place by road-only, than for shipments which make also use of other-than-road vehicles;
- small and medium size firms have higher preferences for safety than larger firms;
- as in Bolis and Maggi (2002), we find that firms adopting a JIT organization have a higher preference for reliability than other firms, especially with regards to the adoption of the JIT system in managing inputs (and therefore affecting there production process);
- firms which outsource inventory as well as transportation have lower quality preferences than firms which outsource transportation only.

One of the main difficulties in analysing freight transport is dealing successfully with its heterogeneity. In the context of a CA experiment, shipments' heterogeneity poses difficulties in setting up an appropriate design and in deriving aggregate results. Since shipments are product, length, firm- and location- specific, they are defined over very different intervals in attribute levels. In order to provide realism to the CA experiment, attribute levels are customised and, as a consequence, relevant attribute-level intervals overlap only partially. For the same reason, it is troublesome to derive meaningful aggregate estimates. In this paper, thanks a software that provides estimates at the individual shipment level, we pursued the opposite path of comparing preferences within specific and interesting segments of the sample and we did find statistically significant differences within the sample. This result sheds some concern on the possibility of developing aggregate mode choice models for freight, but it shed also some light on the possibility of designing effective policies for specific market segments.

Acknowledgments

Financial support by Friuli Venezia Giulia region is gratefully acknowledged.

Notes

[1] The list of possible attributes characterising a freight transport service can be quite long. Lu (2000) listed 33 attributes.

[2] There are also few studies (e.g., Vieira, 1992) that pioneered the conjoint use of both revealed and stated preference data.

[3] Two often used software packages in recent European freight transport research are LASP, developed at Institute of Transport Studies of the University of Leeds (Fowkes and Shinghal, 2002), and MINT, developed by the Hague Consulting.

[4] The ACA manual describes it as follows: "The term "adaptive" refers to the fact that the computer-administered interview is customised for each respondent; at each step, previous answers are used to decide which question to ask next, to obtain the most information about the respondent's preferences….. Questioning is done in an "intelligent" way; the respondent's utilities are continually re-estimated as the interview progresses, and each question is chosen to provide the most additional information, given what is already known about the respondent's values. Respondent utilities are available upon completion of the interview."

[5] The possibility of performing segmentation analysis (which depends on the availability of information on respondent characteristics to be collected during face-to-face interviews), together with the range of qualitative attributes and hypothetical scenarios that can be studied, represents, in our view, one of the main advantages of stated preference

studies as opposed to revealed preference ones. On the other hand, stated preference data can be subject to the so-called hypothetical bias, whereas revealed preferences, which are based on actual behaviour, are not. Combining the two sources of data, consequently, could represent an important way forward in freight transport research.

[6] The choice of the attribute levels will be discussed in the next Section.

22 Goods' safety attributes are rarely included in applied studies. At the theoretical level it was included in the model developed by Allen (1977).

[7] For alternative specifications of safety stock cost see Baumol and Vinod (1970, p. 418) and Vieira (1992).

[8] For more details see Rotaris (2002).

[9] This feature is particularly useful for "categorical" attributes representing discrete variables like brand or colour. Such variables are not included in this experiment. With continuous variables, this feature allows to detect non linearities.

[10] Excluding unacceptable levels has the further positive effect of reducing the number of attribute levels, hence, reducing the number of questions to be asked, shortening the length of interview and avoiding possible fatigue distortions.

[11] Although all these indexes require the linearity of the utility function in relation to the cost factor, which, in our case, is almost verified

[12] A more precise specification of risk attributes should be tested in the future.

[13] Unless a fixed-effect model is estimated, as in Maier and Bergman (2002).

[14] Bolis and Maggi (2002, p. 220) " Our experiments confirmed the view that goods classifications are no longer an important means to analyse transport decisions. While we found no evidence for differences in valuation among sectors, we found high values for high quality goods, and above significant impact on long-term logistics context" and Meier and Bergman (2002, p. 271). Whereas Meier and Bergman (2002, p. 271) "the valuation placed on alternative dimensions of transport services by logistics managers of Austrian companies differs significantly by both their regional and the industrial-cluster affiliation".

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