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.