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Full Length Research Paper

Modeling freight transportation preferences: Conjoint analysis for Turkish Region

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Conjoint analysis is a very popular method used to analyze the structure of consumers' preference. This technique is usually based on stated preference technique. Stated preferences experiments present individuals with hypothetical travel scenarios and seek their preferences. This paper reports the results of a conjoint analysis experiment performed in two Turkish Regions that estimates transportation managers' preferences for freight service attributes. According to results of analysis, the possibility that firms rely on intermodal transportation rather than on road transportation is evaluated. The research project focused on freight transportation demand by cement firms in the Antalya Region, Turkey. In the analysis, data related with the cement transported from City of Eskişehir to the City of Antalya and its surrounding area by road and intermodal transportation modes were used. These data were obtained in a survey conducted in 2007 with 50 cement merchants in Antalya. The empirical results show that time reliability is an important variable determining mode choice. Valuation of cost and time are generally lower than expected.

Key words: Stated preference, conjoint analysis, intermodal transportation, modal choice.

INTRODUCTION

Freight transportation has recently become a significant element in issues involving energy conservation, air pollution, foreign trade, inflation, economic growth and regional development to mention but a few. In discussions on sustainable development and transportation, the concept of intermodal transportation often arises. This is due to the possibility of using the most environmentally friendly mode for each movement in the transport chain. Over the last 60 years, the Turkish economy has changed from a base in heavy industry. Over the same period, the share of road freight transportation has risen from 17.1 – 94.8% in 2007, with a corresponding decrease in rail transportation (TurkStat, 2008).

Because road transportation has been mostly used for freight transportation in Turkey and several other countries, a number of negative impacts have occurred such as increased traffic accidents and air pollution. Primary goal in planning of nation-wide transportation system is to utilize all of the available modes in equilibrium. In this framework, the intermodal transportation has to be considered as a possible alternative to currently accepted road-oriented solutions. In this respect, researchers could use estimate methods of freight service attributes to support their transportation demand models. Several methodologies can be used to analyze how shippers evaluate and select freight transportation services. Conjoint analysis is largely used for purpose in transportation studies on freight transportation. Analytic hierarchical processes, fuzzy logic, genetic algorithms can be given as examples the other methods used (Gursoy, 2010).

In this background, the aim of this paper is to evaluate the characteristics of freight transportation demand with conjoint analysis method. The theoretical background has been obtained through literature studies and theories. These theories have been analyzed and conclusions have been made with the purpose of supporting the

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construction of the model. For this purpose, the logistics managers of 50 companies that sell cement were interviewed during the period, 2007. The interviews were carried out on a laptop computer equipped with the SPSS and ACA software, produced SPSS Inc. and Sawtooth Software Inc. respectively. Conjoint analysis technique was used to evaluate and compare logistics managers' preferences for freight transportation service. In the analysis, data related with the cement transported from city of Eskişehir to the City of Antalya and its surrounding area by road and intermodal modes were used.

This study illustrates data collection and sampling process, followed by a definition of conjoint analysis, description of the model and finally, the estimation results are reported.

METHODOLOGY

Antalya is the biggest tourist attraction center of Turkey, located south of Turkey. Therefore, the population in the city is increasing day in and day-out. As a result of all that, construction industry in Antalya increases enormous. Cement is the basic elements of the building construction sector. Cement is often moved to Antalya from Çimsa Çimento Co. which is located at Eskisehir. There are two transportation modes to move cement from Eskisehir to Antalya. One of them is the road transportation. Other is the intermodal transportation. Since this transportation corridor has a big potential for both types of transportation and demands characteristics knowledge, the transport managers of 50 cement firms whose shipments were used by this corridor were interviewed during the period. The data are gathered to cover the socio-economic features and preferences about freight transportation from each firm. Each interview has been recorded on digital support. The interviews were carried out with a laptop computer equipped with two software packages called ACA, produced Sawtooth Software Inc., which used the first and second phases of interview for arranging and writing computer aided surveys, and SPSS, produced SPSS Inc., which is used for logistic regression and conjoint analysis. The overall response rate was good which resulted in face to face contact with the transportation managers of these firms. Approximately, 80% of the firms approached agreed to be interviewed; and it was only 20% completed interviews that did not yield usable results.

Phase 1 questions were printed as a typical interview form, where respondents entered basic information about the firm. This phase took no more than 10 - 15 min and helped establish the rapport necessary to conduct Phase 2. The second part of the interview contains conjoint analysis test, aiming at gathering data on firms' preferences about transportation service choice. The interview lasted about an hour and half.

Conjoint analysis of stated preferences

At the core of any marketing analysis is an attempt to understand and formalize the behavior of consumers of the product or service. Conjoint analysis which is a very popular method used to analyze the structure of consumer's preference relies upon the assumption that not only one but also many factors affect the purchasing or appreciation (Gustafsson et al., 2001). This technique is usually based on stated preference technique (Darren et al., 2008). Stated Preference techniques have advantages over Revealed Preference methods which are based on actual choices, because the individual can be asked to make more than one freight transportation choice and can be presented with trade-offs rather than dominated choices (Zotti and Danielis, 2004; Kofteci, 2009).

Through a stated preference based survey, respondents are asked to express their preference, to rate, to rank, or to choose between assumptive alternatives which are described with a set of attributes. Typically price and brands are introduced as attributes (Evans, 2008). Therefore, conjoint analysis employs a carefully designed survey in which respondents are given a sequence of questions or choice sets. Conjoint analysis, since its first introduction in the marketing world in the late 60s, has known enormous success (Orme, 2005). Because this method allows predication of choice, the reaction of consumer to product features, notably the price, changes in current products or new products introduced in a competitive market.

Conjoint analysis which is a stated preference based technique is largely used and discussed in transportation studies on freight and passenger transportation (Trawen and Hijalte, 2000). Conjoint analysis approach to consumer behavior is particularly relevant to an understanding of how shippers select between competing modes of transport. Especially, in freight transportation, firms recognize that there are a number of factors which can add to their costs, including the level of loss and damage, additional inventory which must be held to avoid stock outs, the value of in-transit inventory, and the reliability of a mode services.

The conjoint analysis approach is a well-established procedure for collecting stated preference information from respondents. In the context of freight transportation the method has been used among others by Fowkes and Shinghal (2002), Maier et al. (2002), Bolis and Maggi (2003), Zotti and Danielis (2004) and Danielis et al. (2005).

Maier et al. (2002) examined preferences and behavioral stability of product transportation managers against the backdrop of Austrian surface transportation supplier networks (road, rail, water) regarding the freight movement needs of firms within the country and neighboring countries. The key findings of their studies are the reliability of transportation service and related stability factors dominate as the key transportation issue.

Shinghal and Fowkes (2002) used Leed Adaptive Stated Preferences Software (LASP) for the main survey on the Delhi to Bombay corridor. LASP is the software specifically designed for conjoint experiments. The empirical results of this study show that, frequency of service is an important attribute determining mode choice. Valuation of reliability is a generally lower than expected. Value of time is quite similar across different product segments. According to results of this study, it is suggested that intermodal transportation services can be viable for high value and finished goods.

Bolis and Maggi (2003) presented the results of a microanalysis of freight transportation demand in a logistics context. They applied stated preference approach in mode choice analysis in Italy and in Switzerland. They used LASP software for analysis. They calculated marginal values of time and characteristics (reliability, frequency, etc.) According to results of this study, they suggested that if service quality of rail transportation is improved, rail transportation will be more preferred.

Zotti and Danielis (2004) investigated freight transportation demand in the mechanic sector of Friuli Venezia Giulia in Italy. They introduced attribute cut-offs in order to account for a two stage decision process. In this paper, to determine the importance of attributes, three types of statistical method were used. These are multinomial logit model, mixed logit model and latent class model. The results of this study show that transportation mode does not represent a discriminatory choice variable, while attributes related to the quality of service are as important as cost attributes.

Danielis et al. (2005) used conjoint analysis in two Italian regions that estimates transportation manager's preferences for freight service attributes. They used ordered probit model to calculate utility of attributes and ACA software to prepare the survey. Results

Table 1. Results of single logistics regression analysis.

Attribute	β	SE (β)	EXP(B)	-2 LOGL	O-O	WALD	SIG
Mode	0.256	0.028	0.918	153.307	6.505	83.591	0.002
Transportation cost	-0.018	0.011	0.021	343.505	6.307	2.677	0.036
Transportation time	-0.120	0.045	0.158	332.331	17.481	7.111	0.040
Time reliability	0.103	0.043	0.589	270.662	79.150	5.737	0.034
Damages and losses	-0.023	0.005	0.894	327.234	22.578	21.16	0.022

Table 2. Attributes and levels used in conjoint analysis.

Attributes	Levels
Mode	**Intermodal road**
Transportation cost	10% less than the current cost 5% less than the current cost Equal to the current cost 5% more than the current cost 10% more than the current cost
Transportation time	Equal to the current travel time Less than half day from current time More than half day from current time More than one day from current time More than two days from current time
Time reliability	All shipments are on time 80% of shipments are on time 60% of shipments are on time
Damages and losses	No loss and damage Damages and losses approximately equal to 5% Damages and losses approximately equal to 10%

show, on average, a strong preference for attributes of quality (time, reliability, safety) over cost. That is to say, transportation managers indicated a high willingness to pay for quality in freight transportation services, especially for reliability and safety.

Building on this literature, this paper investigates transportation manager's preferences for service attributes in Turkish Region, Antalya, located in south of Turkey.

The survey

Design of survey

Surveys are conducted by face-to face interviews which supported computer –administered software. In the first part of survey, basic information about the firms was taken. The initial questions aim at collecting basic information about the firm and for statistical purposes, the typical input and output flows.

In the second part of the survey, the conjoint analysis interview recorded responses to a randomly varied set of choices directly on the interviewer's laptop computer equipped with the SPSS and ACA software.

Attributes to be used

Attributes determination which will be used in conjoint analysis is very important issue. If the studies are reviewed about mode choice analysis in freight transportation, we can get a result like this: Generally five characteristics are identified as most important to firms in choosing freight transportation service (Cullinane and Toy, 2000). These are transportation costs, transportation time, risk of rate arrival (reliability), risk of damage and lost and service frequency (Abdelwahab, 1998; Oum et al., 1992; Picard and Gaudry, 1997). Therefore, transportation service was described by five characteristics in this study: Transportation mode, transportation costs, transportation time, time reliability (risk of late arrivals) and damages and losses. The attributes presented in this study are appropriated with the theoretical principles of the abstract-mode-inventory model developed by Baumol and Vinod (1970). To check the validity of these attributes, Logistics Regression Analysis (LRA) method is applied. For this purpose, a single LRA was first applied for each attribute. Table 1 shows the results of single LRA. Column 2 gives the results omnibus test for each attribute. This test measures whether the coefficients are meaningful or not. Hypotheses of omnibus test are as follows:

H_0: $\beta_1=0$
H_1: $\beta_1\neq0$

If zero hypothesis is rejected, the value of O-O must be greater than 3,8415 which is the value of one-degree freedom of χ^2. Column 6 gives the O-O value for each attribute. If column 6 is examined, it can be seen that all O-O values for each variable are greater than 3,8415. That means that coefficients of all attributes are meaningful to be used in conjoint analysis according to omnibus test criteria. Column 4 shows the values of odds ratio for each attribute. Odds-ratio is a measure of effect size, describing the strength of association or non-independent between two binary data values. If values of EXP(B) are examined, none of these values are not equal to 1. That means that all attributes are effective on mode selection decision. The results reveal that the all attributes are suitable for use in conjoint analysis. Table 2 presents the five attributes and related levels describing each transportation mode.

Conjoint analysis

ACA software was used for arranging conjoint analysis questions (http://sawtoothsoftware, 2008). ACA software generated 33 questions automatically. 33 questions were divided into 4 groups. These were rating (5 questions), importance (5 questions), pairs (18 questions) and calibration (5 questions) questions. They were asked to indicate the rate of each attributes of the transportation service, according to the scaling of 7 levels (from not desirable to

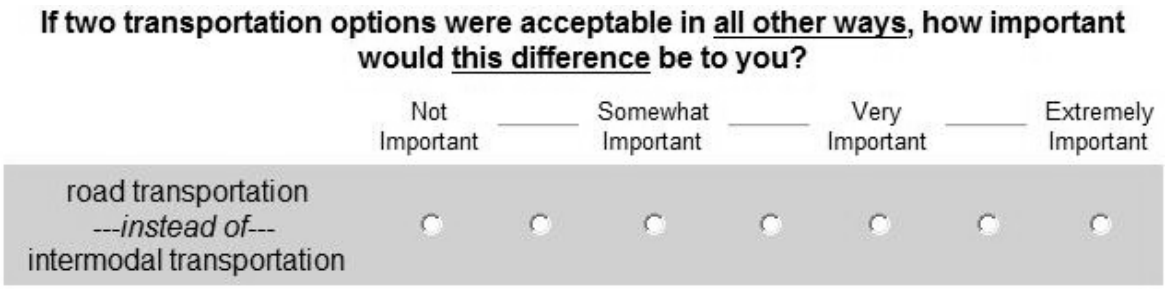

Figure 1. Sample of importance questions.

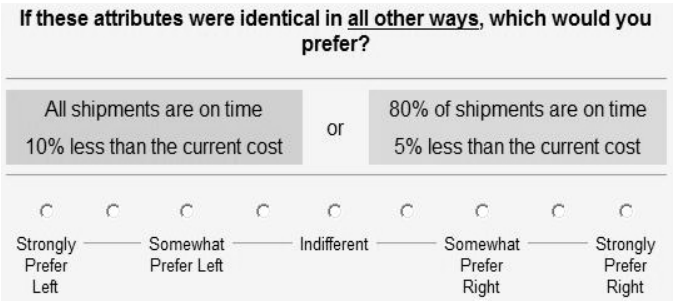

Figure 2. Sample of pair questions.

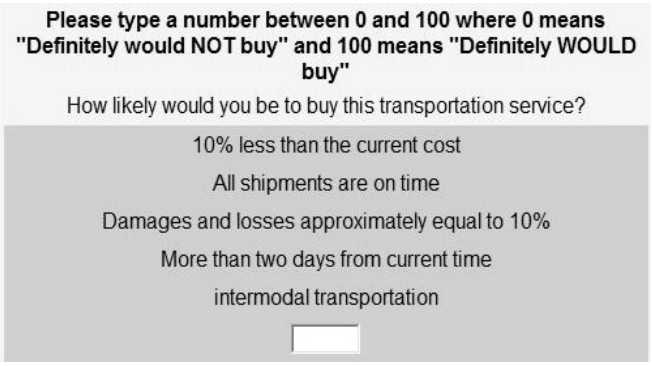

Figure 3. Sample of calibration concepts exercises.

extremely desirable) in the first part of conjoint survey. In the second part of questions, they were asked to indicate the importance of degree of pair of attributes which were selected randomly by software. They were important questions like the one presented in Figure 1.

In the next stage, they were asked to indicate the pair questions. Pair questions were automatically created like any other. Figure 2 presents the sample of pair questions.

In the last stage of conjoint survey, they were asked to indicate the calibration questions, calibration questions like the one presented in Figure 3.

After survey was completed, modeling was done according to the data obtained. SPSS program used calibration of model (http://spss.com, 2008). Because some factors influencing the shipper choices are not measurable (e.g. former experience, prejudgment etc) or measurable (cost, time, etc.), the link between stated choice and attributes is a modeled as a Random Utility Model (Danielis et al., 2005). Random utility models assume, as neoclassical economic theory, that the decision-maker has a perfect discrimination capability. In this context, however, the analyst is supposed to have incomplete information and, therefore, uncertainty must be taken into account. Manski (2004) identifies four different sources of uncertainty: unobserved alternative attributes, unobserved individual attributes, measurement errors and proxy, or instrumental, variables. The utility is modeled as a random variable in order to reflect this uncertainty. Random utility model structure is as follows:

$$U_j^q = V_j^q + \varepsilon_j^q \quad (1)$$

where, U_j^q is a utility function that is perceived by the q individual for the j option. In this model, V_j^q is the deterministic part of the utility and ε_j^q is the stochastic part, capturing the uncertainty.

Utility function also can be expressed as follows:

$$U_j^q = \beta j_1 x_1 + \beta j_2 x_2 + \cdots + \varepsilon_j^q \quad (2)$$

where, β_{jk} coefficients of regression and x_k variables. According to random utility theory, the q individual chooses the alternative A_i if and only if:

$$U_j^q \geq U_i^q, \qquad \forall\ A_i \in A \quad (3)$$

or equivalently if:

$$V_j^q - V_i^q \geq \varepsilon_j^q - \varepsilon_i^q \quad (4)$$

β coefficients can be estimated using a logit or probit model depending on the hypothesis formulated for the characteristics of the probability distribution of the random component. In the analysis in this study, multinomial logit model was used.

Multinomial logit model (MNL) is a regression model which generalizes logistic regression by allowing more than two discrete outcomes. Logit models are derived from the assumption that the error terms of utility functions are interdependent and identically Gumbell distributed. These models were first introduced in the context of binary choice models, where the logistic distribution is used to derive the probability. Their generalization more than two alternative is referred to as multinomial logit models (Ben-Akiva and Lerman, 1985). In this study, five attributes were used for conjoint analysis. Therefore MNL was used for calibration process.

Table 3. Comparison of intermodal and road transportation according to attributes.

	Transportation cost		Transportation time		Time reliability		Damages and losses	
Intermodal transportation is better than the road transportation	30	60.00 %	10	20.00%	15	30.00%	1	2.00%
Intermodal transportation is equal to the road transportation	5	10.00%	1	2.00%	8	16.00%	3	6.00%
Intermodal transportation is worse than the road transportation	15	30.00%	39	78.00%	27	44.00%	46	92.00%
Total	50		50		50		50	

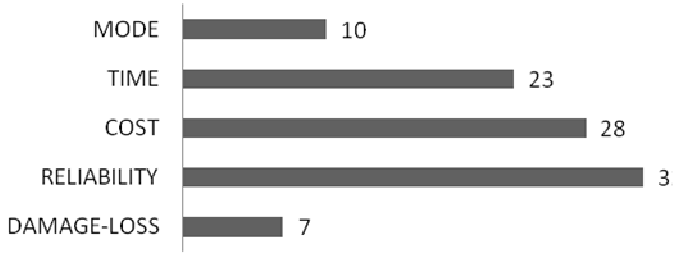

Figure 4. Average importance value for each attribute.

Table 4. Estimation results of Multinomial logit model.

	Coefficient	t- statistic	p-value
Mode	0.1685439	1.003	0.2585
Time	-0.5806533	-2.684	0.0054
Cost	-12.6074843	-7.487	0.0004
Reliab	34.6890358	8.470	0.0002
Damage-loss	-0.03690532	-0.568	0.7450
Constant	-0.57942687	-1.476	0.1569

RESULTS

According to survey results, first general perception of intermodal transportation in current status was depicted in Table 3. Table 3 presents how intermodal transportation is perceived by decision makers which interviewed the person. In each table row, information about the attributes where intermodal transportation is considered better, worse or equal to the road transportation is reported. For example, in the first part of transportation cost column, numbers show how intermodal transportation is perceived by decision makers according to transportation cost perception.

As can be observed from the table, only under the cost aspect the intermodal transportation is perceived better than the road transportation. On the other side, intermodal transportation is considered not convenient based on transportation time, time reliability, damages and losses. Judging by the general public, these results are not surprising.

In the next step, importance of the value of each attribute was examined. This can be calculated automatically by ACA software when each survey is finished. So, the importance of each attribute for each person who was interviewed can be determined. Figure 4 presents average important value of each attribute for all persons which was calculated with the average value method.

The reliability is the most important attribute for mode choice decision as shown in Figure 4. Value of cost is very close to it. The most inefficient variable for mode choice is damage and loss.

In the next step, for calibration of utility model, SPSS program was used. We used MNL model to calculate utility of attributes. The estimate of multinomial logit model is presented in Table 4.

As far as experimental variables are concerned, COST is measured as the costs of the shipment in Turkish Liras (1 TL = 0.67 US $ in 2010); TIME measured the days until the shipment is delivered under regular conditions. For both variables, we expect a negative sign (preference for cheaper transport and short delivery times). RELIAB is measured as the percent of shipments that is delivered in time during a year. Since firms will prefer more reliable service, we expect a positive sign. DAMAGE-LOSS is measured percent of shipments that is damaged or lost. Because of preference for low rates of damaged and lost shipment, it is expected a negative sign. From results in Table 4, it can be seen that all attributes have correct sign. Reliability and cost are statistically significant. Time and mode are less significant than cost and time. Damage and loss are not significant attribute. This means that, firms are indifferent to the damage and loss amount.

If results of Figure 4 and Table 4 are compared, it is seen that both are compatible with each other. This means that, transportation reliability is the most important attribute for mode choice. Following this, cost, time, types of mode used are effective respectively for mode choice decision. Damage and loss are not important attribute for mode choice decision.

DISCUSSION

Improvements in freight transportation can be expected to have important economic effects. This paper summarized the key factors for mode choice in freight transportation that were found in Turkey in a recent survey based on the conjoint analysis of shipper behavior. The data set used for this study is the result of 50 interviews of cement sector firms, which have been realized in the Turkish Region of Antalya. The results obtained from this study belong to the same production sector and are all located in Antalya, Turkey. All these features allow us to support the idea that the information obtained from this study is rather robust.

To the best of our knowledge, this is the first time that freight service valuations based on the conjoint analysis in Turkey have been presented.

In this study, two sets of results have been derived. ACA estimates the utilities, associates each attribute for each experiment and economic estimates of attribute utility within the discrete choice modeling framework. Both estimates indicate reliability of transportation service dominates as the key transportation issue. The damage and loss do not represent a differential choice variable, while cost is almost as important as reliability.

These results confirm that, modal shift policies focus mainly on the reliability aspect of the mode to be promoted. Primarily, if the reliability of intermodal transportation is improved, the possibility that firms rely on intermodal transportation rather than on road transportation will increase. This is very important result for politicians who want to improve intermodal transportation system.

Finally, it can be said that future research would first have to work on a wider base, in order to produce more representative results, and then should try to integrate eventually also the longer-term decisions into the experiment itself.

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