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Trade-Off Analysis Based Freight Mode Choice Model: A Case Study of Turkey

Sevil KOFTECİ
Akdeniz University, Faculty of Engineering, Department of Civil Engineering, 07058, Antalya, TURKEY

*Corresponding Author
e-mail: skofteci@akdeniz.edu.tr

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ABSTRACT

This paper reports the results of an trade-off analysis experiment performed in two Turkish region that estimates transportation managers' preferences for freight service attributes. According to analysis's results, the possibility that firms rely on combined transportation rather than on road transportation is evaluated. The research project focused on freight transportation demand by ceramic firms in the Antalya Region, Turkey. In the analysis, data related with the ceramics transported from city of Çanakkale to the city of Antalya and its surrounding area by road and combined modes were used. These data were obtained in a survey conducted in 2006 with 43 ceramic merchants in Antalya. The empirical results show that time is a most important attribute determining mode choice. Attributes which related quaity level of sevice are generally lower than expected.

Key Words: Transportation choice, trade-off analysis, freight transportation attributes, combined transportation.

INTRODUCTION

Freight transportation is a crucial sector for national economies. Planning freight transportation appropriately influenced not only determining correct investment area but also the factors, which positively affects living conditions, such as environment, trade and economy. Over the last 60 years, the Turkısh economy has changed from a base in heavy industry. Over the same period, the share of road freight transportation has risen from 17,1% to 94,8% in 2007, with a corresponding decrease in rail transportation[1]. Because road transportation has been mostly used for freight transportation in Turkey and several other countries, a number of negative impacts have occured, 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 combined transportation has to be considered as a possible alternative to currently accepted road-orianted 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 analyse how shippers evaluate and select freight transportation services.

Trade-off analysis is largely used for purpose in transportion studies on freight transportation.

In this backrgound, the aim of this paper is to evaulate the chacrateristics of freight transportation demand. For this purpose, the transport managers of 43 ceramic firms were interviewed during the 2006. The interviews were carried out on a laptop computer equipped with the SPSS and ACA demo softweres, produced SPSS Inc and Sawtooth Software Inc. respectively. Trade-off analysis technique was used for evaluate and compare transportation managers' preferences for freight transportation service. In the analysis, data related with the ceramics transported from city of Çanakkale to the city of Antalya and its surrounding area by road and combined modes were used.

Section 2 illustrates the data collection, sampling, defination of trade-off analysis and the variables used in the estimation, survey design and modelling studies. This is followed by a results are presented in section 3. Finally in section 4, modelling results are interpreted.

MATERIALS AND METHODS

Data Collection and Sampling

Antalya is the biggest tourism city in Turkey, region of south of Turkey. Therefore, the population of city is increasing continuously. Because of all that, construction industry in Antalya is enormous. Ceramic is, building material widely used in construction sector. The construction industry in Antalya needs a lot of ceramic-based products. Ceramics are often moved to Antalya from Çanakkale Ceramic Factories Corporation which located Çan. Çan is the district of Çanakkale province. There are two ways to move ceramics from Çanakkale to Antalya. One of them road transportation. Other is combined transportation. Since this transportation corridor has a big potantial about both transportation types and demand characteristics knowledge, the transport managers of 43 ceramic firms whose shipments were used this corridor were interviewed during the 2006. The gathered data cover the socio-economic features and preferences about freight transportation for each firm. Each interview has been recorded on digital support. The interviews carried out with a laptop computer equipped with two software packages called ACA demo, produced Sawtooth Software Inc., which used the first and second phases of interview for arranging and writing computer aided questionnaires, and SPSS, produced SPSS Inc., which used for trade-off analysis. The overall response rate was good, which resulted mainly face to face contact with the transportation managers. Approximately 75% of the firms approached aggred to be interviewed and only % 10 completed interviews did not yield usable results.

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

Trade-Off Analysis

At the core of any marketing analysis is an attempt to understand and formalize the behavior of consumers of the product or service. Trade-off analysis, which is a very popular method used to analyse the structure of consumer's preference, relies upon the assumption that not only one but many factors affect the purchasing or appreciation. Trade-off analysis also called conjoint analysis. This technique is usually based on stated preference technique. Through a stated preference (SP) based survey, respondents are asked to express their preference, to rate, rank, or choose between assumptive alternatives which are described with a set of attributes. Typically price and brands are introduced as attributes. Therefore, trade-off analysis employs a carefully designed questionnaire in which respondents are given a sequence of questions or choice sets. Trade-off analysis since its first introduction in the marketing world in the late 60s, has known a enormous success. Because this method allows predict choice, the reaction of consumer to product features, notably the price, changes in current products or new products introduced in a competitive market.

Trade-off analysis is a stated preference-based technique, largely used and discussed in transportation studies on freight and passenger transportation. Trade-off 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 stockouts, the value of in-transit inventory, and the reliability of a mode's services.

SP techniques have advantages over Revealed Preference (RP) 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 [5].

The trade-off analysis approach is a well-established procedure for collecting stated preference information from respodents. 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); Danielis et al. (2005).

Maier et al. [2] examined preferences and behavioural 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 the country and neighboring countries. The key findings of their study is the reliability of transportation service and related stability factors dominates as the key transportation issue.

Shinghal and Fowkes [3] used Leed Adaptive Stated Preferences Software (LASP) for the main survey on the Delhi to Bombay corridor. LASP is a software which specifically designed for trade-off experiments. The empirical results of this study show that, frequency of service is an important attribute determining mode choice. Valuation of reliability ise generally lower than expected. Value of time 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 [4] 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[5] investigated freight transportation demand in the mechanic's sector of Friuli Venezia Giulia in İtaly. 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 type of statistical method were used. These are multinominal 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 attibutes related to the quality of service are as important as cost attributes.

Danielis et al.[6] used trade-off analysis in two İtalian 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 questionnaire. Results show that, on avarage, a strong preference for attributes of quality (time, reliability, safety) over cost. That is to say, transportation managers indicated a high willignes to pay for quality in freight transportation services, especially for reliability and safety.

Building on this literatüre, this paper investigates transportation manager's preferences for service attributes in Turkish region Antalya, located in region of south of Turkey. Experiments are conducted face-to face interviews which supported computer –administered software. In the first part of questionnaire, basic information about firm were asked. Table 1 presents details on the type of questions asked with .

Table 1. Examples of questions asked in the first part of each interview

- What is your business in the firm?
- According to revenues and employees, which is the size of the firm? (This question is asked according the revenue and employee scale)
- How much product has moved in 2005 from Çanakkale to Antalya?
- How would you describe your firm's production organization?
- What is type of contract is used (FOB factory, FOB destination, other)
- Which activities are outsourced?
- What is the avarage transportation time each transportation activity in 2005?
- What is the mode used each transportation activity in 2005?
- What is the avarage transportation cost each transportati activity in 2005?

The initial questions aim at collecting basic information about the firm and for

statistical purposes, the typical input and output flows.

Phase 2 which the trade-off analysis interview recorded responses to a randomly varied set of choices directly on the interviewer's laptop computer equipped with the SPSS and ACA demo softweres. 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 manufacturing firms in choosing freight transportation service [7]. These are transportation costs, transportation time, risk of rate arrival (reliability), risk of damage and lost and service frequency [8, 9, 10]. Therefore, transportation service was described by five characteristics in this study: Transportation mode, transportation costs, transportation time,time reliablility (risk of late arrivals) and damages and losses. The attributes presented in this study are appropriate with the theorical principles of the abstract-mode-inventory model developed by Baumol ve Vinod [11]. Table 2 presents the five attributes and related levels describing each transportation mode.

Table 2. Attributes and levels used in trade-off test

Attributes	Levels
Mode	Combined 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 approx imately equal to 10%

Later, ACA demo version was used for arranging trade-off questions[12]. 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. It was asked indicate the rate of each attributes of the transportation service, according to the scaling of 7 levels (from not desirible to extremelly desirible) in the first part of trade-off questionnaire. Limit values were determined with the information we get from here.

In the second part of questions, it was asked the indicate the importance degree of pair of attributes which selected randomly by software. Importance questions like the one presented in Fig. 1.

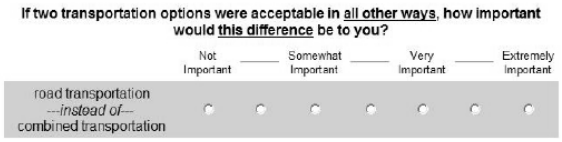

Figure 1. Sample of importance questions

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

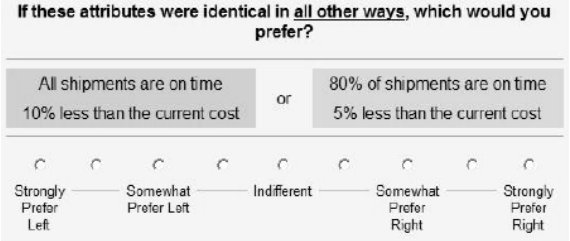

Figure 2. Sample of pair questions

In the last stage of trade-off questionnaire, it was asked indicate the calibration questions. Calibration questions like the one presented in Fig. 3.

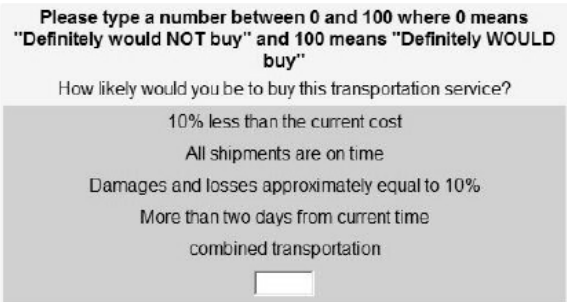

Figure 3. Sample of calibration consepts exercises

After questionnaire was completed, modeling was done according to the data obtained. SPSS program used to calibration of model [13]. Because some factors influecing the shipper choices are not measurable (e.g. former experience, prejudgment etc) or measurable (cos, time etc.), the link between stated choice and attributes is a modelled as a Random Utility Model [6]. 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 [14] 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 percieved 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 uncertainity. Utility function also can be expressed as follows

$$U_j^q = \beta_{j1}x_1 + \beta_{j2}x_2 + \cdots + \varepsilon_j^q \quad (2)$$

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

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

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, multinominal logit model was used.

Multinominal Logit Model (MNL) is a regression model which generalizes logistic regression by allowing more than two discrete outcomes.

Logit models 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 multinominal logit models [15]. In this study, five attributes was used for trade-off analysis. Therefore MNL used for calibration process.

RESULTS

According to questionnaire results, first general perception of combined transportation in current status was depicted in Table 3. Table 3 presents how combined transportation is perceived by decision makers which interviewed the person. In each table row, information about the attributes where combined transportation is considered better, worse or equal to the road transportation is reported.

Table 3. Comparision of combined and road transportation according to attributes

	Transportation cost		Transportation time		Time reliablility		Damages and losses	
Combined transportation is better than the road transportaton	28	65.12 %	11	25.58%	14	32.56%	0	0%
Combined is equal to the road transportation	3	6.97 %	1	2.33 %	10	23.26	5	11.63 %
Combined is worse than the road transportaton	12	27.91%	31	72.09%	19	44.18%	38	88.37 %
Total	43		43		43		43	

As can be observed from the table, only under the cost aspect the combined transportation is percieved better than the road transportation. On the other side, combined transportation is considered to be not convenient as to transportation time, time reliability, damages and losses. Judging by the general public, these results are not suprising.

In the next step, importance value of each attribute was examined. Importance value of each attribute can be calculated automatically by ACA software when each questionnare is finished. So we could determine the importance of each attribute for each person who was interviewed. Figure 4 presents avarage importance value of each attribute for all persons which calculated with the avarage value method.

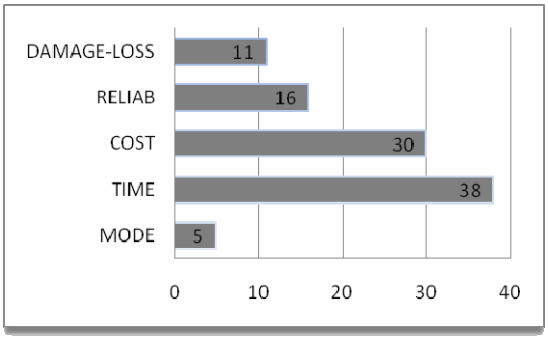

Figure 4. Avarage importance value for each attribute

Figure 4 shows that, time is the most important attribute for mode choice decision. Value of cost is very close to it. Most inefficient variable for mode choice is mode type which used.

In the next step, to calibration of utility model, SPSS program was used. We used MNL model to calculate utility of attributes.

The estimate of multinominal logit model is presented Table 4.

Table 4. Estimation results of Multinominal Logit Model

	Coefficient	t- statistic	p-value
MODE	0.0321	2.756	0.41689
TİME	-46.176	-12.895	0.00014
COST	-13.086	-7.215	0.00067
RELİAB	7.423	4.470	0.03586
DAMAGE-LOSS	-9.590	-5.847	0.25683

As far as experimental variables are concerned, COST is measured as the costs of the shipment in Turkish Liras, TİME is 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). RELİAB 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. Since preference for low rates of damaged and lost shipment, we expect a negative sign. From results in Table 6, it can be seen that all attributes have correct sign. Cost and time are statistically significant. Reliability and damage-loss are less significant than cost and time. Mode is not significant attribute. This means that, firms are indifferent to the which mode used if the quality of service is sufficient.

If results of Fıgure 4 and Table 6 are compared, it is seen that both are compatible with each other. This meant that, transportation time is te most important attribute for mode choice. Following this cost, reliability, damage-loss and type of mode used are effective respectively for mode choice decision. Mode type is not important attribute for mode choice decision.

DISCUSSION

Improvements in freight transportation can be expected to have important economic effects. This paper summarize the key factors for mode choice in freight transportation that were found in Turkey in a recent survey based on the trade-off analysis of shipper behavior. The dataset used for this study is the result of 43 interviews about ceramic sectors, which have been realised in the Turkish region of Antalya. The results obtained from this study belong to the same production sector and are all located Antalya in Turkey. All this features allow us to support the idea that the information obtained from this study are rather robust.

To the best of our knowledge, this is the first time that freight service valuations based on the trade-off analysis have been presented.

In this study, two sets of results have been derived. ACA estimates the utilities associate each attribute for each experiment and economic estimates of attribute utility within the discrite choice modelling framework. Both estimates indicate, time of transportation service dominates as the key transportation issue. The transportation mode does not represent a diffrential choice variable, while cost is almost as important as time.

These results confirms that, modal shift policies focus mainly on the time aspect of the mode to be promoted. Primarily, ıf the time of combined transportation is improved, the possibility that firms rely on combined transportation rather than on road transportation will increase. This is very important result for politicians who want to improve combined 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 than, future research should try to integrate eventually also the longer-term decisions into the experiment itself.

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