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Determinants of combined transport's market share

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Abstract—This research proposes the use of stated preference techniques in order to take into consideration the transport operators' behaviour towards various transport and other parameters, in the prediction of the future modal split between road and combined transport. Through the development of suitable logit models for the corridor Greece–Italy–Northern Europe, the modal choice decisions are put in a wider framework where cost and time parameters are examined together with parameters concerning transport facilities availability, government subsidies and company structure, leading thus to a more complete insight of how modal choice decisions are taken. Forwarders and carriers were treated separately as the former were found to have a significantly more positive approach towards combined transport than the latter. The analysis showed clearly that due to the limited development of the required infrastructure, the most important parameter affecting the future combined transport market share is the level of financial aid to the transport operators for the purchase of the required combined transport equipment. Furthermore, changes in trip cost, trip time and company annual profit due to combined transport are, as expected, parameters affecting the combined transport market share.

Keywords: Freight transport; combined transport; modal choice; modelling; stated preference; behaviour.

INTRODUCTION

In the mid-nineties, environmental problems make necessary the use of 'cleaner' transport modes instead of highly polluting road vehicles. The European Commission (EC) in its white paper for the future development of the common transport policy stresses the importance of a framework for sustainable mobility [1]. An EC Communication [2] on the creation of a European combined transport network and its operating conditions presents the basis for a European Union (EU) policy of promoting combined transport. This policy is also expressed in a recent proposal for decision, defining a trans-European network for transport [3] (Christofersen group), where intermodality and interoperability between transport networks are priority choices for the future.

In parallel, combined transport is strongly supported by the United Nations/Economic Commission for Europe which issued in 1991 the European Agreement on important international combined transport lines and related installations (AGTC) [4]. In addition to its growing importance in Europe, combined transport has recently been officially recognised in the USA and the US Government has passed the US Intermodal Surface Transportation Efficiency Act (ISTEA) on 1991 [5].

The relative market shares of road and combined transport is one of the key issues for the future development of combined transport. Road transport is flexible, sufficiently reliable and easy to manage and operate, whereas rail, the predominant component of combined transport, is environmentally-friendly, efficient for long distances, and more economic in the use of energy. The prediction of future market share between road and combined transport is of major importance for the definition of long term policies at all levels (local, national, international). A substantial amount of research has already been done on this topic.

An important effort has been made in recent years to identify of parameters affecting the modal choice between road and combined transport [6, 7]. These parameters are classified in performance parameters (transport time, frequency, reliability, regularity and capacity limits), cost parameters (price, price effects due to variations, index agreements, credit agreements), service quality parameters (loss and damage rate and its administration, tracking and tracing, documentation, communications, reception confirmation, customer delivery and handling services, schedule flexibility), and general parameters (company structure/organization, government interventions and available transport facilities) [8]. The identification of the contribution of each parameter to the final modal choice has also been investigated recently, as discussed below.

There are various methods for the identification of future modal split in freight transport [9, 10]. A general but rather simple approach for a pan-European modal split between road and combined transport has been proposed by Kearney [11]. This method employs a matrix with relatively reliable and uniform data for actual flows between each origin–destination pair of European regions and with a number of macro-economic assumptions for the future development of the freight transport sector in Europe. On this basis a new matrix is produced where combined transport's market share is identified for each origin–destination pair.

NEA [6] developed a framework for parameters and time phases in road and combined transport that allowed a cost based comparison of the two competitive modes. According to the NEA model the equilibrium point where freight may shift from road transport to combined transport is dictated by the compensation required for the inferior service of combined transport. This NEA approach was the basis for the development of the EC-SIMET [12] model. This consisted of a linear programming cost-based optimization algorithm for the assignment of freight flows on the European multimodal network to make it competitive with international road transport and to ensure that the total costs of the European transport system are minimized.

Dornier [13] developed another model for the prediction of combined transport's market share. The Dornier–Transkombi model uses a modal split function (logit function) which is defined as a logistic distribution function. With this distribution the probability of combined transport being selected is defined as a function of road transport time and cost, of combined transport time and cost and of the maximum market share of combined transport.

Another approach using micro-economic analysis, is adopted in the model of INRETS [14], which is based on 'market areas' theory. According to this theory, by searching out all the places for which combined transport offers the most competitive means of transport, the market area of a transhipment centre is defined. This market area evolves according to several parameters. The use of this method allows the specification of features that make combined transport become a competitive transport offer.

Most of the above models are based on fixed assumptions about the operator's behaviour towards changes in transport parameters and calculate the future market share according to changes in transport parameter values. This calculation is rather static and cannot adequately represent the future market as it is based on the users' revealed preference for an existing service and not on the users' stated preference for a future service. Furthermore, most of the above models rely too heavily on the economic cost parameters and too little on service quality and behavioural parameters [8].

This research proposes the use of stated preference techniques, so that on the basis of the transport operator's likely response to future sets of transport parameters, a more reliable estimate of the future modal split between road and combined transport is achieved. On the basis of the stated preference survey data a logit model is developed.

It is noted that stated preference techniques were originally developed in marketing research in the early 1970s [15], and have been widely used since the end of that decade in the marketing of new products [16] and services [17] as well as in the modal split of urban passenger transport. Future market share between private cars and public transport in urban passenger transport systems is often predicted by models considering the stated preference of the users towards changing transport parameters [18, 19].

FIELD SURVEY

This research examines Greek transport demand for freight transport services on the combined transport corridor from Greece through Italy to Northern Europe [20] by means of the stated preference method. Greece is situated in the Balkan peninsula, in the south-east of Europe, with the Adriatic Sea forming a frontier between Greece and Italy, the closest EU neighbour of Greece. Consequently, a Greek road carrier willing to reach other European Union states has to cross either the sea (to Italy) or non EU countries (ex-Yugoslavia, Bulgaria, etc.) [21, 22]. The road–sea–rail combined transport itinerary has to face numerous problems due to the lack of appropriate rolling stock (swap-bodies, etc.) and suitable infrastructure (special equipment in ports and warehouses, etc.) and of inadequacies in the organizational and legislative frameworks [23].

The population of the present survey is constituted by all transport operators in Greece, the number of which is estimated to be in the range of 1200. The sample unit used was the individual transport operator who evaluates road transport and combined transport alternatives and chooses the one which offers the greatest utility.

The sample size was carefully determined to be representative of the population and sufficient for the estimation of the coefficients with a satisfactory level of accuracy. A sample size of 112 observations was finally chosen, taking into account the results of another work [24] which suggest that for a population in the range of 1000, at least 100 observations are required to keep the coefficient estimation error within 25% at the 80% confidence level.

During the survey, Greek transport carriers and forwarders were interviewed. The carriers are those that possess a vehicle fleet and are expected to be those who will possess the required loading unit fleet. It should be mentioned that due to the existing structure of the freight industry in Greece, carriers rarely have the resources to invest combined transport systems. It is the forwarders who typically organize the combined transport operation as they often have the necessary financial resources to invest in combined transport equipment.

The carriers and forwarders interviewed have been selected in a way to form a representative sample of the Greek transport operators. The sample contained a mix of companies varying in size, specialization in heavy/light and agricultural/industrial products, location in south and north Greece, serving Italy, Germany, and Western Europe, and in their relative use of freight transport on the Greece–Italy sea corridor and Balkans land corridor.

The survey focused on two origin–destination pairs between Greece and the European Union regions: Greece–Milan and Greece–Köln. These two pairs account for the majority (70–80%) of freight flows [25] between Greece and the EU. As a consequence, they are considered representative of the transport demand between Greece and EU, which is expected to predominate in the Greece–Italy–Northern Europe combined transport corridor.

THE QUESTIONNAIRE

The interviews with the Greek operators were supported by a questionnaire specially designed for the survey. This questionnaire contained some questions which referred generally to the corridor and others which related to specific aspects of the service. It, therefore, shed light both on operators' overall attitude towards the corridor and the effects of various service parameters on their behaviour. The questionnaire explored the trade-off that firms make between modal attributes.

The questions attempted to determine the relative weight attached to different parameters, considered each time in pairs [26]. For each pair a number of different scenarios were considered assuming changes in the values of two parameters. Scenarios with zero change for one of the two parameters were also considered. For each of the above scenarios the respondent had to choose between road and combined transport.

The attribute-related parameters included in the questionnaire were carefully selected from a comprehensive list. These parameters, with their corresponding value ranges were: (a) round-trip cost change due to a switch to combined transport (values range from −30 to +30% of the existing road round-trip cost); (b) round-trip time change due to a switch to combined transport (values range from −3 days to +3 days in relation to the existing road round-trip time); (c) the existence of guaranteed delivery time; (d) the annual profit increase resulting from a switch to combined transport (values range from +10 to +30%); and (e) the operator's participation (with equity) in the required investment for combined transport equipment (values range from 30 to 100%).

Particular characteristics of the operators were considered, as it was thought that they could significantly affect mode choice. These characteristics included the company profile (carrier or forwarder), the company size (turnover, number of employees, number of vehicles), the company equipment and warehouses available, the company activity areas in Greece and abroad, the annual number of trips per vehicle, and finally the use of computer communication.

To ensure that the operator had a complete and clear idea of the combined transport corridor and the alternative scenarios, an explanatory document accompanied the questionnaire [27]. During the completion of the questionnaire, care was taken to ensure that the operator contributed not only his opinion about the choice of scenarios but also his qualitative justification for each of his choices [28]. This qualitative justification cannot of course be used in the model development but it assists the interpretation of the model results.

GENERAL ATTITUDE DESCRIPTION

The answers of the Greek operators show the relative importance they assign to the transport parameters considered. Their attitude is summarized in the following points:

- The majority of both Greek carriers and forwarders declare that they are not willing to pay more reduced transit time.
- They are much more willing to trade-off longer transit times for lower rates.
- Forwarders and carriers are unwilling to pay more for a guaranteed delivery time.
- There are significant differences in the annual profit increases that would be required to justify a switch to combined transport. For example, 78% of carriers would transfer to combined transport for a 20% rise of their annual profit whereas the corresponding percentage of forwarders is only 52%.
- Most Greek operators would need significant financial incentive to switch to combined transport. According to the majority of both carriers and forwarders, they would require financial support in the region of 70% of the total capital cost of acquiring combined transport equipment.

While these results provide useful insights into transport operators' preferences, they do not provide an adequate basis for forecasting future combined transport market share. For this purpose, one must develop a quantitative model.

MODEL DEVELOPMENT

General

In order to estimate the future demand for combined transport in the Greece–Italy–Northern Europe corridor, advanced models were developed. The models are the outcome of logit analysis, which is commonly employed in transport mode choice situations, to identify key parameters that are significant in affecting these choices. Logit models can explain and predict many aspects of consumer behaviour, giving insight into the main variables determining the consumers' current preferences, and allowing predictions about their future choices [29].

The input data for choice analysis models comes either from the observation of actual consumer choices (revealed preference data) or from the elicitation of responses to hypothetical choice scenarios (stated preference data). In the analysis of transport-related choices, the term stated preference refers to the use of individual respondents' statements about their preferences in a set of transport options [30]. These options are typically descriptions of transport situations or contexts constructed by the researcher. The more recently developed techniques allow stated preference analyses to move beyond the examination of preference structures to a direct examination of choice processes [31]. Although it is possible to elicit useful information by asking respondents to rank or rate the alternatives presented to them, it is usually considered preferable to put the questions in a behavioural choice context and ask for discrete choices [32].

Population segmentation

The basic objective of the modelling exercise was to make aggregate predictions of each mode's choice. Thus, although the operative decision making unit is the individual operator, accurate predictions about the behaviour of groups of such individuals are required. In order to reduce the errors when the actions of operators are aggregated and thus to improve the modelling results, a market segmentation approach [33] was applied to derive separate individual choice models for various groups [34]. Furthermore, the segmentation approach allows consideration of how various policies impact on each of the segments separately.

It was decided to segment the population on the basis of type of operator and final destination. It should be noted that choice-set determination is one of the main issues in developing discrete-choice models. The crude method, which is commonly used,

Table 1.
Two-way population segmentation

Transport operator	Final destination	
	Milan	Köln
Carrier	33	37
Forwarder	65	54

assumes that everybody has all alternative modes available. This has the disadvantage of producing a model which incorporates unrealistic options and may not be able to distinguish adequately between more realistic choices [35]. The segmentation approach adopted in the following analysis, which distinguishes among different choice-set groups, addresses this problem [36]. Separate models are developed for carriers and forwarders.

Preliminary data analysis showed that cost and time values related to Milan trips are significantly different to those related to Köln trips. Given that some cost and time variables were expressed as percentages and not in money terms it would not be sensible to include Milan and Köln trips in the same model, because the value-of-time in this case (as expressed as a percentage of cost per day, instead of currency units per day) would not be comparable for the two destinations. Thus, model development distinguished between the two final destinations considered. The above considerations led to the two-way segmentation shown in Table 1 with the corresponding sample sizes for each sub-group.

The same carrier or forwarder may be involved in freight transport either to Milan or to Köln, on the basis of the existing demand. Thus, there is overlap between the samples of carriers for each destination subgroup in Table 1; the same applies to the samples of forwarders.

The variables considered

The data used in the analysis are based on the answers to the questionnaires. More specifically, the following variables were considered in the model development procedure (Table 2).

Table 2.
The variables considered

General information on the transport operator
Company annual turnover (in Drs)
Staff employed by the company (in number of persons)
Fleet size (in number of vehicles)
Use of micro-computers/LANs/main frames (yes/no for each case)
Communication by phone/telex/fax/computers (yes/no for each case)
Number of trips per vehicle per year
Serving areas in southern/northern Greece (yes/no for each case)
Serving areas close to Milan/Köln (yes/no for each case)
Clients structure (percentage of occasional clients to total)
Information concerning combined transport (CT) trip details
Annual profit increase with CT (in percentage)
Trip-cost savings with CT (in percentage)
Trip-time savings with CT (in number of days)
Guarantee of delivery time by CT (yes/no)
Possibility to trace shipment in CT (yes/no)
Flexibility on choosing CT shipments (yes/no)
Operator's participation in the required CT investment (in percentage)

Analysis

Disaggregated binary logit models [37] were developed for the prediction of mode choice between combined transport and road transport alternatives. Given that there are only two alternatives, the utility of the road alternative is set to zero. The software used for the estimation of the coefficients of the utility functions was the A-logit [38].

The results of the above procedure also include statistics for the evaluation of the goodness of fit of the model to the data as well as the significance of the variable coefficients in the model. The goodness of fit of the model is tested with the corrected ρ^2 index [39], which is given by:

$$\rho^2 = 1 - \frac{l^*(\theta)}{l^*(c)},$$

where: $l^*(\theta)$ is the maximum log-likelihood at convergence and $l^*(c)$ is the log-likelihood at convergence of the constants only model (market share).

The model specification search for each sub-group was initiated by checking whether the models should contain alternative specific constants, using the likelihood ratio (LR) test [40]. It was necessary to include alternative specific constants in all the models for the subgroups considered. A number of alternative model specifications were then tested for each subgroup and the results of these tests analysed. Models with different combinations of the various variables considered were developed and assessed. As far as the significance of the coefficients of the model variables is concerned, the t-statistic was used [41].

Variables were included in the models if they had coefficients significantly different from 0 at the 5% level of significance or if they had an insignificant coefficient but the improvement to the likelihood function was significant, as measured by the likelihood ratio test [36, 40, 42]. Numerous different ‘paths’ were tried in the context of these significance tests, operating the LR-test both ‘backward’ to the null model and ‘forward’ to the more complete model. The variables finally included in the models are presented in Table 3.

Analysis of the survey data using A-logit produced the four models presented below for the combined transport utility U_{CT}. The number in brackets underneath each coefficient is the t-test value.

Table 3.
Variables included in the models

C:	round-trip cost change due to combined transport compared to the existing road round trip cost [$= (C_{\mathrm{CT}} - C_{\mathrm{ROAD}})/C_{\mathrm{ROAD}}$ in %, ranging from −30 to +30%],
T:	round-trip time change due to combined transport compared to the existing road round trip time [$= T_{\mathrm{CT}} - T_{\mathrm{ROAD}}$ in days, ranging from −3 days to +3 days],
P:	the company’s annual profit increase due to combined transport compared to the existing annual profit using road transport (in %, ranging from +10 to +30%),
I:	the operator’s participation in the investment for the purchase of the required combined transport equipment (in %, ranging from +30 to +100%) and
CC:	a dummy variable denoting whether the firm uses computer communication for the coordination of its activities (coded 1 for yes and 0 for no).

Milan — carriers

$$U_{\mathrm{CT}} = \underset{(-8.4)}{-1.1150} - \underset{(-5.8)}{0.0384^{*}C} - \underset{(-4.2)}{0.5262^{*}T} + \underset{(4.8)}{0.0731^{*}P} - \underset{(-4.8)}{0.0653^{*}I} \quad (\rho^2 = 0.1807).$$

Milan — forwarders

$$U_{\mathrm{CT}} = \underset{(-7.8)}{-0.7176} - \underset{(-9.4)}{0.0561^{*}C} - \underset{(-5.2)}{0.4520^{*}T} + \underset{(6.7)}{0.0769^{*}P} - \underset{(-7.3)}{0.0659^{*}I} \quad (\rho^2 = 0.1803).$$

Köln — carriers

$$U_{\mathrm{CT}} = \underset{(-8.4)}{-0.9650} - \underset{(-5.7)}{0.0342^{*}C} - \underset{(-5.3)}{0.4253^{*}T} + \underset{(5.3)}{0.0742^{*}P} - \underset{(-5.3)}{0.0593^{*}I} \quad (\rho^2 = 0.1698).$$

Köln — forwarders

$$U_{\mathrm{CT}} = \underset{(3.7)}{-0.6879} - \underset{(-7.8)}{0.0396^{*}C} - \underset{(-5.3)}{0.3316^{*}T} + \underset{(6.5)}{0.0813^{*}P} - \underset{(-6.7)}{0.0624^{*}I} + \underset{(3.1)}{0.5013^{*}CC}$$
$$(\rho^2 = 0.1598).$$

It can be seen that the cost and time related variables have significant coefficients at the five percent level of significance in all four models.

It is also worth noting that both for carriers and forwarders the corresponding coefficients have higher values for Köln than for Milan. This result seems to suggest that the time and cost effects are less important on longer distance combined transport trips. On the other hand, the length of haul does not appear to affect operators' willingness to invest in combined transport facilities. This is to be expected as capital investment decisions are more likely to depend on higher level assessments of the available business opportunities.

Model assessment

By changing the value of one parameter and keeping all other values constant, the sensitivity of combined transport to this parameter can be investigated. This sensitivity was investigated for all model parameters by assigning to each parameter values that vary within the range which was used in the questionnaire. The selection of the range of parameter values was based on reasonable expectations concerning the combined transport corridor under consideration in the future. The application of the various values to the model parameters led to the computation of the utility U_{CT} of combined transport, which was then used in the binary logit formula $P_{\mathrm{CT}} = \exp(U_{\mathrm{CT}})/[1 + \exp(U_{\mathrm{CT}})]$ to calculate the probability (P_{CT}) of the use of combined transport corridor. This probability obviously represents the combined transport market share expressed as a percentage of the total market share.

On the basis of this analysis, it was possible to draw a number of conclusions about the combined transport market share. These conclusions are summarized below.

- The most important parameter is the need for the operator to make a capital investment in combined transport. It is the only parameter whose variation can produce significant combined transport market share changes. The importance of this parameter shows clearly that financial support for capital investment will be required to promote the development of combined transport. This should take priority over improvements in other combined transport parameters.
- Variations in the three other parameters (cost, time, profit) have little impact on the combined transport market share. Of these, the potential annual profit increase has slightly greater effect than the other two.
- The comparison of the four cases shows clearly that the lower combined transport market shares are observed for carriers serving Milan, followed by carriers serving Köln and forwarders serving Milan, and the highest combined transport market share percentages are observed for forwarders serving Köln. This result reconfirms the widely accepted view that combined transport is more competitive over longer distances. Furthermore, forwarders opt for combined transport more easily than carriers in the corridor considered, because it entails much smaller organizational and financial changes for them than for carriers. The nature of these changes for transport operators strongly influences attitudes to combined transport.
- In the case of forwarders serving Köln the use of computer communication by the company has an important impact on combined transport's market share, increasing it by between 20 and 40%. It is clear that this parameter is also an indicator of the company's approach towards innovation. This suggests that more innovative companies are more likely to switch to combined transport.

CONCLUSIONS

The relationship between modal choice and the various transport and other explanatory parameters is not straightforward due to the complexity and variety of the interactions involved [8]. The research reported in this paper has tried to establish the relationship between these parameters and combined transport's market share using stated preference techniques. The model examines the role of a number of transport parameters that are not separately considered in most of the classic methods, which tend to apply a common metric (e.g. generalized cost) for all alternatives is used. The results of this work put modal choice decisions in a wider framework where cost and time parameters are examined together with parameters relating to transport facilities, government subsidies and company structure, thus leading to a more complete picture of how modal choice decisions are taken.

It became clear in the early stages of the analysis that carriers' attitudes to combined transport differ from those of forwarders. This is due to the fact that the carriers have more limited organizational and financial capabilities than forwarders. Forwarders and carriers were considered separately in the analysis. The models revealed that in general, for a given set of transport parameter values, the forwarders are more willing to switch to combined transport than carriers. It should be mentioned however, that the need for separate mode choice models for forwarders and carriers is expected to diminish as differences in their organizational and financial structures narrow.

The analysis of survey data showed clearly that for both carriers and forwarders the most important parameter affecting the future combined transport market share in the corridor examined is the level of external financial support for the purchase of combined transport equipment. This conclusion must of course be qualified by the acknowledgement that in the case of the corridor examined, several important features of the combined transport operations were poor (e.g. standard of infrastructure and company culture) and this was discouraging the growth of combined transport. This is clearly reflected in the results of the model application, where even for the optimistic scenario the combined transport market share is disappointingly low. It can be argued that the importance of external financial aid to transport operators depends on the required level of the investment facilities and equipment.

Improvements in freight rates, transit times and company annual profits resulting from a switch to combined transport are the next most important parameters affecting the choice of combined transport. Detailed discussions with transport operators revealed that in freight market segments where combined transport can play a role, operators are more interested in keeping the transport cost low than in shorter transit times.

The existence of computer communication seems to have a positive effect on combined transport choice only for long distance trips. Such trips are in fact chains composed of a considerable number of separate 'links', the co-ordination of which is significantly facilitated by computer communication. This necessity is obviously decreasing as the trip length and number of the chain links decrease. Additionally, the use of computer communication by a transport company reflects a positive attitude towards technological and other innovations, which tends to be associated with a positive attitude towards combined transport too.

Modal choice decisions appear not to be related to the size of a company where the organizational structure has been developed without any provision for the combined transport requirements. Market experience confirms that there is no reason company size should affect the likelihood of choosing combined transport. The survey results also suggest that guaranteed delivery time is not a parameter affecting modal choice. This can be attributed to the fact that, for the types of traffic for which combined transport is considered an alternative mode, punctual arrival of a consignment is not a critical factor. This conclusion confirms existing experience [43].

Finally, the model indicates that transport operators are more keen to choose combined transport for longer trip distances. This is in accordance with the commonly accepted view [2] that combined transport has a comparative advantage in long distance movement.

The results presented here relate to a particular case study, i.e. the combined transport corridor from Greece through Italy to Northern Europe. As a consequence, they are valid only for cases with similar conditions. Caution should be exercised in extrapolating these results to other corridors. The demand for freight transport is directly influenced by the level, composition and geographical distribution of production and consumption activities, while that modal choice depends on specific needs and perceptions of those involved in the day-to-day dispatch of freight. In such a complex situation it is highly unlikely that a universal mode choice model can be developed.

An important outcome of this work is the further confirmation that the use of the stated preference technique seems to work quite successfully in this context [44]. It can effectively determine transport operators' attitudes towards different alternative transport modes and quantify the effects of the predominant parameters on the final mode choice through the development of a logit model.

Logit models can be developed by use of the stated preference technique for the prediction of combined transport's market share in other similar corridors in Europe with a potential for combined transport. The combined use of these models could support the development of a European strategy for combined transport and to provide guidance on the design of combined transport services.

The results of the present analysis suggest that for combined transport's share of the freight market to be increased significantly, there will be a need for serious government intervention in the freight market, particularly through the provision of financial support to operators.

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