Determinants of combined transport 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 image 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.

Key-words: freight transport, combined transport, modal choice, modelling, stated preference, behaviour

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Introduction

In the mid-nineties, environmental problems make necessary the use of "cleaner" transport means 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]. In the EC Communication[2] concerning the creation of a European combined transport network and its operating conditions, the basis for a European Union (EU) policy aiming at the reinforcement of combined transport is put. This EU policy for the promotion of combined transport 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 market share between 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 a mode 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 in all levels (local, national, international) and substantial work has already been undertaken in this sector.

An important effort has taken place over the last years towards the identification 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[8] (company structure/organisation, government interventions and available transport facilities). The identification of the contribution of each parameter to the final modal choice has also been investigated recently, as shown 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 A.T. Kearney[11]. According to this method, on the basis of 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, a new matrix is produced where combined transport 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 substandard service of combined transport. This NEA approach was the basis for the development of the EC-SIMET[12] model, which consisted of a linear programming cost based optimisation algorithm for the assignment of freight flows on the European multimodal network so that it is competitive with international road transport and so that the total costs of the European transport system are minimised.

Dornier[13] developed another model for the prediction of combined transport 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 selection probability of combined transport 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 follows the market areas theory. According to this theory, by searching out all of 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 ingredients that make combined transport become a competitive transport offer.

Most of the above models are based on fixed assumptions for 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 can not represent sufficiently the future market as it is based on the users' revealed preference for an existing service and not in 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 behaviour towards 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 the changing transport parameters[18, 19].

Field survey

This research considers the investigation of Greek transport demand for the combined transport corridor Greece - Italy - Northern Europe[20] and applies the stated preference method to this case study. Greece is situated in the Balkan peninsula, at the south-east of Europe, and Adriatic sea forms a sea 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.), of suitable infrastructure (special equipment in ports and warehouses, etc.) and of the appropriate relative combined transport culture (legislation framework, sector organisation, etc.)[23].

The population of the present research 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 with the greatest utility for himself. 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 1.000, at least 100 observations are required to keep the coefficient estimation error within 25 percent at the 80 percent confidence level.

During the survey Greek transport carriers and forwarders were interviewed. The carriers are those that possess the 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 transport companies structure in Greece, carriers are rarely in the position to invest as required for the promotion of combined transport. The forwarders are those organising the transport procedure and very often are those having the sufficient financial resources to make the required investments in necessary 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 interviewed consisted of small and big companies, specialised in heavy/light and agricultural/industrial products, located in South and North Greece, serving Italy, Germany and Western Europe in general, and using for freight transport not only the Greece - Italy sea corridor but also the Balkans land corridor.

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

The questionnaire

The interviews with the Greek operators were supported by a questionnaire specially designed for the survey. The questionnaire comprised questions not all of them referring directly to the corridor itself but to various elements and parameters related to it, so that the answers could lead to conclusions on the operators behaviour towards the corridor and the effects that various parameters have on this behaviour. The questionnaire used the trade-off technique in order to derive conclusions for the conditions which are necessary for the use of combined transport.

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

The attribute related parameters finally included in the questionnaire were carefully selected from the already mentioned respective exhaustive lists of parameters in an attempt to summarise all the basic trends in a space limited ergonomic design of the questionnaire. The parameters selected as well as the corresponding value ranges considered are: a) round-trip cost change due to combined transport (values range from -30% to +30% of the existing road round-trip cost), b) round-trip time change due to combined transport (values range from -3 days to +3 days in relation to the existing road round-trip time), c) the existence of guarantee of delivery time, d) the annual company profit increase due to the company 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%).

Furthermore, parameters related to the particular characteristics of the operators were considered , as it was thought that they could significantly affect mode choice. More specifically the parameters included in the questionnaire refer to 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 has a complete and clear idea of what the combined transport corridor will be and which will be the alternative scenaria, an explanatory document was accompanying the questionnaire[27]. Furthermore, during the completion of the questionnaire, care was taken that the operator contributed not only his opinion for the alternative scenaria choice but also his qualitative justification for each of his choices[28]. This qualitative justification can not of course be used in the model development but it is useful during 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 summarised in the following points :

- The majority of both Greek carriers and forwarders declare that they are not willing to pay more for a shorter trip. Trip cost sacrifices in favour of trip time economies are not accepted by the Greek operators.
- Trip time sacrifices in favour of trip cost economies seem reasonable to the Greek operators.
- Forwarders and carriers do not accept to pay more for the guarantee of delivery time.
- Greek carriers and forwarders have a different approach for the annual profit rise that would justify a switch to combined transport. Thus, for example, the percentage of carriers that would transfer to combined transport for a 20 percent rise of their annual profit is 78 percent while the corresponding percentage of forwarders decreases to 52 percent.
- A significant financing aid is considered by the Greek operators necessary for switching to combined transport. Thus, for example, according to the opinion of the majority of both carriers and forwarders the appropriate level of financial aid should be in the range of 70 percent of the total investment for the purchase of the required combined transport equipment.

Although these results show the basic trends of the transport operators' behaviour, they are not sufficient for the extraction of valid conclusions for the future combined transport market share. Therefore, the development of a tool that would help in the quantification of the above share was considered necessary.

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 those parameters that are significant in affecting these choices. Logit models can, as a matter of fact, 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 scenaria (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 on 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 estimate separate individual choice models for various groups[34]. Furthermore, the segmentation approach allows consideration of various policies impacts on each of the segments separately.

It was decided to segment the population on the basis of kind 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 brute force method, usually used, assumes that everybody has all alternative modes available. It presents the disadvantage of leading to a model which, by being capable of dealing with unrealistic options by assigning very low probabilities to them, may not be able to describe adequately the choices among the realistic ones[35]. The segmentation approach adopted in the following analysis, which distinguishes among different choice-set groups, contributes towards handling this problem[36].

The use of the kind of operator as a segmentation parameter was decided, because it was expected to influence the importance that various variables have in the decision process. Thus, separate models are developed for carriers and forwarders.

Furthermore, preliminary data analysis showed that cost and time values related to Milan are significantly different to those related to Köln. Given that some cost and time variables were expressed in percentages and not in money terms it would not be sensible to include situations related to Milan and Köln in the same model, because the value-of-time in this case (as expressed in 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.

It is noted that obviously the same carrier or forwarder may be involved with freight transport either to Milan or to Köln, on the basis of the existing demand. Thus, the samples of carriers for each destination subgroup considered in Table 1 has an overlapping; the same applies for the corresponding samples of forwarders.

Table 1. Two-way population segmentation

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

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. The variables considered

<u>*General Information on the transport operator*</u>

- 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)

<u>*Information concerning combined transport (CT) trip details*</u>

- 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

Disaggregate 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 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 the 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

$l^*(c)$: 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]. Alternative specific constants were found necessary to be included 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 test were 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 zero at the five percent level of significance or if they had non significant coefficient but the improvement to the likelihood function was significant, as measured by the likelihood ratio test[40, 42, 36]. 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 developed are presented in Table 3.

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_{CT}-$C_{ROAD)}$)/C_{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_{CT}-T_{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).

Analysis of the survey data by use of 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.

Milan - Carriers

U_{CT} = - *1.1150* - *0.0384**C - *0.5262**T + *0.0731**P - *0.0653**I (ρ^2=0,1807)
(-8.4) (-5.8) (-4.2) (4.8) (-4.8)

Milan-Forwarders

U_{CT} = - *0.7176* - *0.0561**C - *0.4520**T + *0.0769**P - *0.0659**I (ρ^2=0,1803)
(-7.8) (-9.4) (-5.2) (6.7) (-7.3)

Köln - Carriers

U_{CT} = - *0.9650* - *0.0342**C - *0.4253**T + *0.0742**P - *0.0593**I (ρ^2=0,1698)
(-8.4) (-5.7) (-5.3) (5.3) (-5.3)

Köln - Forwarders

U_{CT} = - *0.6879*-*0.0396**C-*0.3316**T+*0.0813**P-*0.0624**I+*0.5013**CC (ρ^2=0,1598)
(3.7) (-7.8) (-5.3) (6.5) (-6.7) (3.1)

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 advantages related to combined transport for long distance trips render the time and cost effects less important for such combined transport trips. On the contrary, no such indication can be traced for the operator's participation in the investment required. This is a rather reasonable result as decisions concerning capital investment are expected to depend on criteria regarding the macroscopic aspects of the specific business and not the corresponding details.

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 questionnaire range for the 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 $P_{CT} = \exp(U_{CT}) / [1 + \exp(U_{CT})]$ 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.

The above procedure led to the extraction of a number of conclusions outlining some important characteristics of combined transport market share. These conclusions are summarised below.

- The parameter affecting the most the combined transport market share is the participation of the operator in the investment required. It is the only parameter whose variation can produce significant combined transport market share changes. This parameter importance shows clearly that combined transport markets which are not developed, need important financial aid for investment in combined transport equipment, before any other improvement in transport parameters.
- The variation of the three other parameters (cost, time, profit) has little impact to the combined transport market share. Among them, annual profit has slightly more important effects 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 longer distances can attract more combined transport traffic than shorter distances. Furthermore, forwarders opt for combined transport more easily than carriers in the corridor considered, because the corresponding organisational and financial implications are closer to their actual activities than those of the carriers. Thus, the organisational and financial level of the transport operators seem to be factors affecting significantly the attitude towards combined transport.

- In the case of forwarders serving Köln the use of computer communication by the company has an important impact to the combined transport market share as it increases this market share by a percentage ranging from 20% to 40%. It is clear that this parameter is also an indicator of the company's approach towards innovation and therefore the real meaning of this result is that companies engaged to innovation developments are also more keen to switch to combined transport.

Conclusions

The development of an algorithm, supported by a logical explanatory framework with regard to mode choice for freight transport, is of great interest for modern management, where decisions in the logistical area are becoming more and more integrated with issues in the production and commercial areas.

It should be noted that the choice of transport mode is possible for specific segments of the freight transport market. For the remaining segments the nature of the goods to be transported, e.g. regular bulk consignments, perishable foodstuff, etc., determine in a predominant way a single transport mode to be used.

The development of a model which can determine the combined transport market share, when this alternative is possible, on the basis of a number of policy and other explanatory variables, is of great importance as it may dictate the necessary steps towards the future evolution of combined transport.

The relationship between modal choice and the various transport and other explanatory parameters is not straightforward due to the complexity and variety of interactions involved[8]. This research establishes a number of links between these parameters and combined transport market share with the use of stated preference techniques. The model developed reveals the role of a number of transport parameters not taken into consideration in most of the classic methods, where mainly a common metric (e.g. generalised 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 concerning transport facilities availability, government subsidies and company structure, leading thus to a more complete image of how modal choice decisions are taken.

It became clear in the early stages of the analysis that carriers have a significantly different behaviour towards combined transport than forwarders. This is due to the fact that the carriers considered have in general low organisational levels and limited financial capabilities while on the contrary forwarders have in general a high standard organisational and financial structure, very near to that required for the support of combined transport and sometimes even better. Thus, forwarders and carriers were considered separately in the analysis. The corresponding models developed reveal that in general, as expected on the basis of the above explanation, all other parameter values being the same forwarders are more keen to switch to combined transport than carriers. It should be mentioned however, that the necessity for developing different mode choice models for forwarders and carriers is expected to decrease as their differences in the organisational and financial structure become smaller.

The survey data analysis showed clearly that both for carriers and forwarders the most important parameter affecting the future combined transport market share in the corridor under consideration is the financing level that can be ensured as an external aid to the transport operators for the purchase of the required combined transport equipment. This conclusion must of course be evaluated together with the fact that in the case study considered some important factors related to combined transport (existing combined transport infrastructure and related culture) are rather negative creating thus a rather hostile environment for further development of the combined transport. This is clearly reflected in the results of the model application, where even for the optimistic scenaria the combined transport market share is disappointedly low. As a consequence, it can be argued that the importance of the financial external aid to transport operators depends on the level of the total investment for the acquisition of the required combined transport infrastructure. For freight markets requiring low total further investment the external financial aid is expected to have a less significant role in the development of combined transport.

Improvements in trip cost, trip time and company annual profit due to switch to combined transport are next in importance parameters affecting the choice of combined transport among alternative transport modes. It should also be mentioned that through the detailed discussions with the transport operators during the interviews it was revealed that for the freight market segments where combined transport can play a role, operators are more interested in keeping the transport cost low than in achieving trip time gains.

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 partial “links”, the co-ordination of which is significantly facilitated by computer communication. This necessity is obviously decreasing as the trip length and hence the 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 leads to an expectation for a positive attitude towards combined transport too.

It is also worth mentioning that modal choice decisions do not depend on the company size parameter if its organisational structure has been developed without any provision for the combined transport requirements. Market experience confirms that in this case there is no reason why an operator of a certain size would choose combined transport easier than an operator of another size. Furthermore, according to the survey results the guarantee of delivery time is not a parameter affecting modal choice. This must be mainly due to the fact that for the cases that combined transport is considered as an alternative mode, the punctual arrival of the consignment is not a critical factor. This conclusion confirms existing experience[43].

Finally, it is interesting to note that the model application results reveal 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 most advantages of combined transport subside for short distance trips.

The models developed in this work as well as the corresponding conclusions refer obviously to the conditions of the case study considered, i.e. the combined transport corridor Greece - Italy - Northern Europe. As a consequence, they are valid only for cases with similar conditions, while their use in other cases should be attempted with great precautions, if at all. It should be taken into account that the demand for freight transport is directly influenced by the level, composition and geographical distribution of production and consumption activities and furthermore that modal choice depends on specific needs and perceptions of those involved in the day-to-day dispatch of freight. Therefore, in such a complex situation it is highly unlikely that a universal mode choice model can be developed.

However, an important outcome of this work is the conclusion that the use of the stated preference technique for the determination of the transport operators attitude towards different alternative transport modes and for the quantification of the effects of the predominant parameters on the final mode choice through the development of a logit model, seems to work quite successfully.

Logit models can therefore be developed by use of the stated preference technique for the prediction of the combined transport market share in other similar corridors in Europe with a potential for combined transport. The combined use of these models could serve as a tool for the formation of a strategy towards the future development of combined transport in Europe and for the well supported planning of the required actions in relation to the different transport parameters affecting the above strategy implementation.

Thus, if in the context of a global transport policy an increase is decided for the extremely low combined transport market share predicted, even for the optimistic scenaria, by the models in the corridor Greece - Italy - Northern Europe, serious governmental interventions should be imposed on the corresponding freight market including among others, significant financial aids to the operators in the form of subsidies and loans with favourable conditions.

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References

1. Commission of the European Communities (1993), “White Paper : The future development of the common transport policy. A global approach to the construction of a Community framework for sustainable mobility”, COM(92) 494 final, Office for Official Publications of the European Communities, Luxembourg.
2. Commission of the European Communities (1992), “Communication from the Commission concerning the creation of a European combined transport network and its operating conditions”, COM(92) 230 final, Office for Official Publications of the European Communities, Luxembourg.
3. Commission of the European Communities (1994), “Community guidelines for the development of the trans-European transport network”, COM(94) 106 final, Office for Official Publications of the European Communities, Brussels.

[4] United Nations / Economic Commission for Europe (1991), “European Agreement on important international combined transport lines and related installations (AGTC)”, United Nations, Geneva.
[5] The Economist (1993), “The return of the railroads ?” *The Economist*, New York.
[6] NEA (1992), “Framework for parameters and time phases in road and combined transport”, NEA, Rijwick.
[7] Ljungstrom B.L.G. (1985), “Changes in transport users´ motivations for modal choice : freight transport”, European Conference of Ministers of Transport, Round Table 69, Paris.
[8] Jeffs V. and Hills P. (1990), “Determinants of modal choice in freight transport: a case study”, *Transportation*, Kluwer Academic Publishers, Netherlands.
[9] ECMT (1982), “Review of demand models”, Report of the fifty-eight round table on transport economics, OECD, Paris.
[10] Terziev M.N., Ben-Akiva M. and Roberts P.O. (1975), “Freight demand modelling : a policy sensitive approach”, Centre for Transportation Studies, Massachusetts Institute of Technology, CTS report number 75-6, Cambridge.
[11] A.T. Kearney (1989), “Strategic study into a European combined transport network”. A.T. Kearney.
[12] Commission of the European Communities (1994), “Economic and technical research of the transfer of goods : design and evaluation of rapid transfer : SIMET”, DOC.EURET/387/94, Brussels.
[13] Dornier (1993), “Description of the Transkombi model”, DORNIER, Friedrichshafen.
[14] Nierat P. (1991), “Market areas of transhipment centres, theoretical construction or tool for analysis?”, EC seminar on terminals and cargo centres, Brussels.
[15] Green P.E. and Srinivasan V. (1978), “Conjoint analysis in consumer research: Issues and outlook”, *Journal of Consumer Research*, vol.5 pp.103-212.
[16] Louviere J.J. and Woodworth G. (1983), “Design and analysis of simulated consumer choice or allocation experiments : an approach based on aggregate data”, *Journal of Marketing Research*, American Marketing Association, pp. 350-367.
[17] Hensher D.A. and Louviere J.J. (1983), “Identifying individual preferences for international air fares : an application of functional measurement theory”, *Journal of Transport Economics and Policy*, pp. 225-245.
[18] Golias J. (1994), “Investigation of urban sea lines operation in Piraeus-South suburbs”, Hellenic Bank for Industrial Development, Athens.
[19] Hall R.W. (1983), “Traveller route choice: travel time implications of improved information and adaptive decisions”, *Transportation Research*, Vol. 17A, No3.
[20] National Technical University of Athens / Department of Transportation Planning and Engineering (1994), “Investigation of Greek transport demand for the combined transport corridor Greece-Italy-Northern Europe”, NTUA/DTPE, Athens.
[21] Giannopoulos G. and Assimakis M. (1993), “Thematic evaluation in transport, country report for Greece”, CEC DG XVI-B, Booz - Allen & Hamilton, Athens.
[22] Ministry of Transport and Communications (1993), “Transport to and from Greece”, Ministry of Transport and Communications, Athens.
[23] Uniontransporti (1993), “Feasibility study relating to a pilot project on the Greece-Italy-Germany combined transport route”, UNIONTRASPORTI, Milan.
[24] Koppelman F.S. and Chu C. (1983), “Effect of sample size on disaggregate choice model estimation and prediction”, *Transportation Research Record* 944 pp. 60-69.
[25] Trademco (1991), “Study for the management and the promotion of Greek products to the Western and Northern European markets”, Hellenic Bank for Industrial Development, Athens.
[26] Fowkes T. and Wardman M. (1988), “Design of SP travel choice experiments, with special reference to taste variations”, *Journal of transport economics and policy*, Volume XXII, no 1.
[27] Mahmassani H.S. and Tong C.C., “Availability of Information and dynamics of departure time choice : experimental investigation”, *Transportation Research Record* 1085.
[28] Bradley M. (1988), “Realism and adaptation in designing hypothetical travel choice concepts”, *Journal of Transport Economics and Policy*, Volume XXII, no 1.
[29] Louviere J.J. (1988), “Conjoint analysis modelling of stated preferences”, *Journal of Transport Economics and Policy*, Volume XXII, no 1.
[30] Kroes E.P. and Sheldom R.J. (1988), “Stated Preference Methods: An introduction”, *Journal of Transport Economics and Policy*.

[31] Pearmain D. and Kroes E. (1990), “Stated preference techniques : a guide to practice”, Steer Davies & Gleave, Hague Consulting Group, Surrey, UK.
[32] Hensher D.A., Barnard P.O., and Truong T.P. (1988), “The role of stated preference methods in studies of travel choice”, *Journal of Transport Economics and Policy*.
[33] Mcfadden D. and Reid F. (1975), “Aggregate travel demand forecasting from disaggregate behavioural models”, *Transportation Research Record* 534 pp.24-37.
[34] Hensher D.A. (1976), “Use and application of market segmentation”, In: Behavioural Travel - Demand Modelling, Lexington: Lexington Books.
[35] Ruijgrok C.J. (1979), “Disaggregate choice models: an evaluation”, In New Developments in Modelling Travel Demand and Urban Systems, Saxon House, Westmead.
[36] Ortuzar J.D. and Willumsen L.G. (1994), “Modelling Transport”, John Wiley and Sons, West Sussex.
[37] Ben-Akiva M. and Lerman S.R. (1985), “Discrete Choice analysis: Theory and Application to Travel Demand”, The MIT Press, Cambridge/Massachusetts.
[38] Hague Consulting Group (1992), “ALogit Users' Guide” (Version 3.2), Hague Consulting Group.
[39] Tardiff T.J. (1976), “A note on goodness-of-fit statistics for probit and logit models”, *Transportation* 5(4) pp.377-388.
[40] Horowitz J.L. (1982), “Specification tests for probabilistic choice models”, *Transportation Research* 16A(5) pp.383-394.
[41] Ortuzar J.D. (1982), “Fundamentals of discrete multimodal choice modelling”, *Transport Reviews* 291) pp.47-78.
[42] Gunn H.F. and Bates J.J. (1982), “Statistical aspects of travel demand modelling”, *Transportation Research* 16A(5) pp.371-382.
[43] Cemat (1993), “Feasibility study for the combined transport corridor Greece-Italy-Germany”, UIRR/CEMAT, Milan.