CENTRE OF PLANNING AND ECONOMIC RESEARCH

No 94

Consumer Demand Analysis of Complementarities and Substitutions in the Greek Passenger Transport Market

Theodore Tsekeris

September 2007

Theodore Tsekeris

Research Fellow
Centre of Planning and Economic Research, Athens, Greece
e-mail of correspondence: {tsek@kepe.gr}

Consumer Demand Analysis of Complementarities and Substitutions in the Greek Passenger Transport Market

CENTRE OF PLANNING AND ECONOMIC RESEARCH

The Centre of Planning and Economic Research (KEPE) was established as a research unit, under the title "Centre of Economic Research", in 1959. Its primary aims were the scientific study of the problems of the Greek economy, the encouragement of economic research and the cooperation with other scientific institutions.

In 1964, the Centre acquired its present name and organizational structure, with the following additional objectives: first, the preparation of short, medium and long-term development plans, including plans for local and regional development as well as public investment plans, in accordance with guidelines laid down by the Government; second, the analysis of current developments in the Greek economy along with appropriate short and medium-term forecasts; the formulation of proposals for stabilization and development policies; and third, the additional education of young economists, particularly in the fields of planning and economic development.

Today, KEPE focuses on applied research projects concerning the Greek economy and provides technical advice on economic and social policy issues to the Ministry of Economy and Finance, the Centre 's supervisor.

In the context of these activities, KEPE produces four series of publications, notably the *Studies,* which are research monographs, *Reports* on applied economic issues concerning sectoral and regional problems, and *Statistical Series* referring to the elaboration and processing of specifies raw statistical data series. Finally, it publishes papers in the *Discussion Papers* series, which relate to ongoing research projects.

Since December 2000, KEPE publishes the quarterly issue *Economic Perspectives* dealing with international and Greek economic issues as well as the formation of economic policy by analyzing the results of alternative approaches.

The Centre is in a continuous contact with foreign scientific institutions of a similar nature by exchanging publications, views and information on current economic topics and methods of economic research, thus furthering the advancement of economics in the country.

Ανάλυση της Συμπληρωματικότητας και Υποκατάστασης των Επιβατικών Μέσων Μεταφοράς στην Ελλάδα με ένα Σύστημα Εξισώσεων Ζήτησης

Θεόδωρος Τσέκερης

ΠΕΡΙΛΗΨΗ

Η εργασία αυτή παρέχει μια συνολική ανάλυση των σχέσεων συμπληρωματικότητας και υποκατάστασης μεταξύ όλων των επιβατικών μέσων μεταφοράς για εγχώριες μετακινήσεις στην Ελλάδα μεταξύ της περιόδου 1994-2004. Το προτεινόμενο πρότυπο βασίζεται στη θεωρία της καταναλωτικής ζήτησης και η εξειδίκευσή του ακολουθεί τη γενικευμένη μορφή του Σχεδόν Ιδανικού Συστήματος Εξισώσεων Ζήτησης (Almost Ideal Demand System). Για τον προσδιορισμό των πολύπλοκων σχέσεων μεταξύ των μορφών ζήτησης για διαφορετικά μεταφορικά μέσα, η παρούσα εργασία χρησιμοποιεί στοιχεία χρονοσειρών που αναφέρονται σε κάθε Περιφέρεια (NUTS II) της χώρας. Τα στοιχεία αυτά βασίζονται στους τρεις πιο πρόσφατους Εθνικούς Οικογενειακούς Προϋπολογισμούς (ΕΟΠ) της Εθνικής Στατιστικής Υπηρεσίας της Ελλάδας (ΕΣΥΕ) των ετών 1994, 1999 και 2004, στους οποίους η γεωγραφική διαίρεση των νοικοκυριών αντιστοιχεί στην υφιστάμενη διοικητική διαίρεση των 13 Περιφερειών.

Το πρότυπο εκτιμά το μερίδιο των οικογενειακών δαπανών για τη χρήση κάθε μέσου μεταφοράς (όχημα Ι.Χ., αστικό λεωφορείο και τρένο, ταξί, υπεραστικό λεωφορείο και τρένο, πλοίο και αεροπλάνο) σε σχέση με τις συνολικές δαπάνες για μετακινήσεις. Εκτός από τις επεξηγηματικές μεταβλητές των τιμών και του εισοδήματος, το πρότυπο λαμβάνει υπόψη την επίδραση επιπρόσθετων παραγόντων της ζήτησης, οι οποίοι σχετίζονται με τα δημογραφικά και κοινωνικά χαρακτηριστικά των οικογενειών, καθώς και τα πληθυσμιακά και χωροταξικά χαρακτηριστικά των Περιφερειών. Η μαθηματική μορφή του προτύπου αφορά σε ένα εκτεταμένο σύστημα εξισώσεων τύπου panel (με διαχρονικά και διαστρωματικά στοιχεία). Η επίλυση του προτύπου χρησιμοποιεί τεχνικές παλινδρόμησης εξισώσεων τύπου panel, οι οποίες ενσωματώνουν τις σταθερές επιδράσεις κάθε έτους και στρώματος (Περιφέρειας) των παρατηρήσεων στην εκτιμώμενη ζήτηση.

Γενικά, τα αποτελέσματα που προκύπτουν από την εκτίμηση του προτύπου είναι σύμφωνα με την οικονομική θεωρία της ζήτησης και αναμενόμενα ως προς τα ιδιαίτερα χαρακτηριστικά της λειτουργίας της Ελληνικής αγοράς των επιβατικών μεταφορών. Συγκεκριμένα, όλα τα επιβατικά μέσα μεταφοράς βρέθηκαν ότι είναι κανονικά αγαθά, όπως προκύπτει από το θετικό πρόσημο των έμμεσων (ως προς τις συνολικές δαπάνες μετακινήσεων) και άμεσων (ως προς το πραγματικό διαθέσιμο εισόδημα) εισοδηματικών ελαστικοτήτων. Με βάση το μέγεθος των εισοδηματικών ελαστικοτήτων, τα μεταφορικά μέσα μπορούν να διακριθούν σε αναγκαία αγαθά (όχημα Ι.Χ., αεροπλάνο, πλοίο) και αγαθά πολυτελείας (ταξί, λεωφορεία και τρένα), σε αντίθεση με άλλες εργασίες οι οποίες αντιμετωπίζουν τις μεταφορές ως ενιαίο αγαθό. Οι εκτιμήσεις των ελαστικοτήτων των ιδίων τιμών δείχνουν ότι, σε αντίθεση με τα υπόλοιπα μέσα μεταφοράς, η χρήση των οχημάτων Ι.Χ. είναι ιδιαίτερα ανελαστική.

Οι εκτιμήσεις των σταυροειδών ελαστικοτήτων των τιμών αναφέρονται στις εισοδηματικά μη αντισταθμιστικές (κατά Marshall) και τις εισοδηματικά αντισταθμιστικές (κατά Hicks) ελαστικότητες. Οι τιμές αυτές δείχνουν ότι υπάρχουν σημαντικές σχέσεις υποκατάστασης μεταξύ των υπεραστικών δημόσιων μέσων μεταφοράς (κυρίως, των αεροπλάνων, πλοίων, και λεωφορείων και τρένων) και, σε μικρότερο βαθμό, μεταξύ των οχημάτων Ι.Χ. και των αστικών δημόσιων μέσων μεταφοράς. Οι σχέσεις συμπληρωματικότητας είναι λιγότερες από αυτές της υποκατάστασης, και εντοπίζονται κυρίως μεταξύ των αστικών και υπεραστικών δημόσιων μέσων μεταφοράς. Τα αποτελέσματα της εργασίας μπορούν να συνεισφέρουν στην διαμόρφωση και αξιολόγηση κατάλληλων μέτρων οικονομικής πολιτικής για την ενίσχυση της διατροπικότητας και τον επαρκή ανταγωνισμό μεταξύ των δημόσιων μέσων μεταφοράς, και τη βιώσιμη ανάπτυξη των επιβατικών μεταφορών, μέσω της διαχείρισης της ζήτησης για χρήση οχημάτων Ι.Χ.

ABSTRACT

This paper provides an aggregate analysis of the substitution and complementarity relationships among all available transport modes for domestic travel in Greece within the period 1994-2004. The proposed model is based on consumer demand theory and builds on the Almost Ideal Demand System. It processes information concerning both the temporal and spatial variability of demand, as well as factors influencing the travel budget allocation of Greek households. The results obtained from this application of an extended panel demand system reveal the different natures of distinct travel commodities. Also, they indicate the existence of significant substitution as well as complementarity relationships in the Greek passenger transport market. The findings of the study can provide useful insights for the formulation and assessment of transport policies which focus on managing travel demand by private vehicles and increasing the (integrated) usage of public transport modes.

1. Introduction

The issue of intermodality – that is, the combined use of transport modes over a journey – plays a key role in the design, planning and analysis as well as the performance of modern transport systems. The operation of intermodal passenger transport services is strongly influenced by the horizontal market structure, where competition may take place between different modes. Based on classical economic theory, transport modes can be considered as either competitive (or substitutive) or complementary commodities, according to whether the demand for them moves in the opposite or the same direction when the price of one of them changes. Knowledge of the existence and size of substitution and complementarity is crucial for the regulation of the passenger transport market, the marketing and strategic planning of the public transport firms, the decoupling of economic development from travel demand and the promotion of more energy-efficient and environment-friendly modes.

In particular, there are ongoing efforts of governments in the European Union (KPMG, 1997) and other countries (NCP, 1999) to determine suitable measures for regulating the passenger transport market and assessing the impact of deregulation on market shares and the economic performance of transport firms. These policy initiatives stress the need for estimating relevant own- and cross-price elasticities for different transport modes. Moreover, the increasing complexity of passenger travel patterns, the rapid growth of transport technology and the ongoing initiatives for provision of integrated passenger transport services have resulted in changes in the traditional patterns of competition in the transport market, particularly with regard to the inter-urban public transport modes (Givoni and Banister, 2007). This fact signifies the need for the development and implementation of systematic approaches which allow for the investigation of complementarity and substitution relationships among passenger transport modes.

Several travel demand models have been employed to jointly estimate changes in both the levels and shares of demand for two or more passenger transport modes (see Gaudry, 1998). Most of these models, such as those based on trip generation, abstract- mode, gravity-type, modal-split and discrete-choice (e.g. logit) approaches, typically rely on *a priori* restrictions on the demand elasticities and intermodal substitutability, which are irrelevant to the economic theory of demand. This paper presents the formulation and application of a theory-consistent analytical approach for the estimation of income, own and cross-price elasticities of travel demand, based on aggregate data concerning all available passenger transport modes in Greece. The presence and extent of substitution and complementarity are examined within a system-wide panel demand modeling framework. Such a framework encompasses both time series and spatial information, at the regional level, for the travel demand by mode, transport prices and income of Greek households. The proposed panel demand system has an extended form, in the sense that it includes the effects of several factors influencing travel demand by different modes, other than those of prices and income, through the incorporation of appropriate control variables in the model specification.

The modeling system uses household travel expenditures as a proxy for travel demand and it processes aggregate information obtained from the last three waves (1994, 1999 and 2004) of the Greek Household Budget Survey (HBS) for the thirteen Regions of the country. Section 2 presents a critical review of the application of consumer demand systems in the passenger transport sector. Section 3 describes the formulation of the proposed demand system and the relationships used for calculating the various elasticity measures. Section 4 provides descriptive information about the data used in the study. Section 5 presents the results of the model estimation, Section 6 discusses potential policy implications of these results, and Section 7 summarizes and concludes.

2. Theoretical background

A number of empirical studies can be found in the literature for the system-wide analysis of transport expenditure patterns. These studies employ either time series or cross-section data at the aggregate or disaggregate (individual or household) level, which are mostly obtained from the system of National Accounts and consumer expenditure surveys respectively. The analysis of trip expenditures with disaggregate information is typically based on cross-section data from consumer surveys, which do not help determine the competitiveness among transport modes, since prices are held constant and their effect is considered as fixed. Such approaches include the use of systems of Engel functions with instrumental variables (Bergantino, 1997) and discrete choice (limited dependent variable) models for the analysis of household expenditures for public transport and car petrol consumption (Asensio et al. 2003a; Asensio et al. 2003b; Nolan, 2003). The present study concentrates on the aggregate analysis of passenger travel demand in order to investigate substitution and complementarity relationships between all available transport modes.

System-wide consumer demand models can be described as simultaneous systems of expenditure equations that approximate the utility-maximizing behavior of consumers. In the current context, consumer demand models can allow the joint determination of different mode choice preferences by considering cross-price effects. There has existed for some time a variety of demand systems for investigation of the budget allocation preferences of consumers (for a comprehensive review, see Andrikopoulos and Brox (1997)). These include the Linear Expenditure System (LES) of Stone (1954), the translog system of Christensen et al. (1975) and the Rotterdam system of Theil (1976). However, the Almost Ideal Demand System, referred to here as AI (Deaton and Muellbauer, 1980), is considered to be the most empirically robust and consistent with the general theories of demand and choice. The AI system is based on a two-stage budgeting process where, first, utility-maximizing consumers allocate their total budget between travel and the other commodities, and, then, allocate expenditures among individual travel commodities. This process allows us to treat the travel market separately from the rest of the commodity market.

Nonetheless, until now the only studies that have been developed and have tested models for competition between different transport modes are based on earlier demand systems, rather than that of the AI, In particular, Oum and Gillen (1983) used a translog function to derive direct demand equations, in terms of the income spent on three different modes (airline, railway and bus), goods and other services. Moreover, Andrikopoulos and Brox (1990) used a Generalized Linear Expenditure System (GLES) for estimating travel demand for four competitive passenger transport modes (airline, railway, bus and auto). Both of these studies focused on the nation-wide aggregate modeling of the inter-city travel demand in Canada for all trip purposes and trip distances.

Existing studies for the aggregate analysis of transport demand using the AI system typically consider transport as a single commodity group, which is used in the model specification as part of a group of other commodities, such as those of communications, leisure etc. (see Fujii et al., 1985; Mergos and Donatos, 1989). Nonetheless, different forms of transport, such as those related to private car usage and the various public transport services, involve different decision-making mechanisms concerning the allocation of money expenditures. Moreover, private vehicle purchase expenses generally refer to durable goods and long-term investment decisions, and they should be distinguished from (non-durable) trip expenses, which are mostly involved in the daily activity participation process and vacation-making decisions. Besides, urban and inter-city public transport by different modes should be considered as separate commodities, since they involve different decision-making mechanisms and service characteristics. The AI demand system used in this study includes demand equations corresponding to all available modes (private car, urban public transport, taxi, coach, rail, coast-wise sea ferry and airplane) to enable full examination of competitiveness in the domestic passenger transport market in Greece.

Furthermore, the AI approach has been used to investigate the consumption demand share in separate transport markets, including railway passenger travel (Rolle, 1997), private road vehicle transport (Oladosu, 2003) and air passenger travel for leisure purposes (Njegovan, 2006). However, the scope of these studies is restricted, in the sense that they do not cover the whole range of available mode choices and, hence, they cannot adequately consider substitution and complementarity effects in the complete transport market. Additionally, existing consumer demand models have not yet adequately addressed the effects of important determinants of demand, other than income and prices, on transport expenditure allocation decisions. In particular, such determinants can be related to socio-demographic characteristics of households, the size of household vehicular stock, public infrastructure investments, and factors related to congestion costs and economies of agglomeration, which can considerably affect the allocation of household mobility investments. The use of these additional variables, along with the standard information about prices and income, results in the so called extended AI demand system (Tridimas, 2002).

In addition, the use of information about the geographic as well as time variability of the determinants of consumer demand has received limited attention in the existing aggregate demand systems (Denton et al., 1999). The inclusion of cross-sectional information permits the analysis of demand over a wide variety of areas with heterogeneous travel behavior (Andrikopoulos and Terovitis, 1983). The effects of the spatial variations in prices, income and other explanatory variables, such as household characteristics, on travel demand cannot be typically discernible in the standard formulation of the AI system. This is because of the usual shortness of available time series and the correlation between the long-run trend effects and the smoothly changing influences of the determinants of demand over time. The present modeling formulation suggests the use of panel information, which leads to the development of an extended panel AI demand system, allowing the representation of these regional variations in the demand equation of each transport mode.

3. Panel system of demand equations

The present model provides a system of interrelated panel demand equations for the aggregate estimation of the income and price elasticities related to each transport mode, in consistency with the utility-maximizing behavior of users and the constraints imposed by the demand theory. The model follows the standard formulation of the AI demand system (Deaton and Muellbauer, 1980), augmented with a set of additional (linearly translated) factors affecting demand (Pollak and Wales, 1978; Pollak and Wales, 1981; Tridimas, 2002). It employs a panel data structure, which includes both time and spatial (regional level) information about the model variables, as in (Denton et al., 1999). Specifically, after stacking the data for each demand equation for mode i according to time for simplifying the demonstration of the model specification, the linearly approximated AI demand system which is employed here can be expressed as follows:

$$w_i = \alpha_i + \sum_i^M \gamma_{ij} \log P_j + \beta_i [\log X - \log \mathbf{P}] + \sum_k^K \delta_{ik} G_k + \mathbf{L} + \theta_r S_r + u_i \tag{1}$$

where α_i is the constant of the equation of each mode i, $\gamma_{ij} = (1/2)(\gamma'_{ij} + \gamma'_{ji})$ and $\log \mathbf{P} = \sum_j^M w_j \log P_j$, as approximated through Stone's price index, which allows the set of equation (1) to be estimated as a linear system of equations. The functional form of equation (1) expresses the household budget share w_i for mode i as a function of prices P_j, real travel expenditures, as they are provided by the difference of the logarithms of the total travel expenditures X and the price index $\mathbf{P}$, and a set of additional determinants $\mathbf{G}$ of demand, which implies $M \times (K-1)$ additional δ_{ik} independent parameters. Moreover, $\mathbf{L}$ refers to the dummies capturing time-specific effects, S_r are local-specific dummies corresponding to each region r, where θ_r is a column of ones, and $u_i \sim N(0, \sigma^2)$ are the random disturbances of each equation, capturing departures from the utility-maximizing behavior of consumers, e.g., due to lack of information.

Equation (1) suggests that the demand shares are functions of the vector of prices, $(P_1, \ldots, P_M)$, real income (expenditures), $X/\mathbf{P}$, and additional factors, $(G_1, \ldots, G_K)$. Holding prices, expenditures and effects of additional factors constant implies that the demand shares also remain constant. For constant relative prices and additional factors, and variable expenditures, the demand-share change depends on the magnitude and sign of the β_i coefficients. In particular, if β_i>0, the w_i will increase with an increase in expenditures, designating that the i th travel commodity is a luxury, and vice versa for β_i <0, which indicates that the i th travel commodity is a necessity. The theory of demand implies that the following constraints should hold on the parameters:

Aggregation constraints: $\sum_i^M \alpha_i = 1$, $\sum_i^M \gamma_{ij} = 0$, $\sum_i^M \beta_i = 0$, $\sum_i^M \delta_{ik} = 0$ (2)

Homogeneity constraints: $\sum_j^M \gamma_{ij} = 0$ (3)

Symmetry constraints: $\gamma_{ij} = \gamma_{ji}$ (4)

Of the above constraints, aggregation is automatically satisfied, provided that the data add up, whereas the negativity constraint cannot be ensured by any restriction on the α_i, β_i and γ_{ij} parameters alone. The present study provides a framework of normative analysis to investigate the possibility of complementarity or substitution among different transport modes. For this reason, the specification of the linear system of panel demand equations imposes the constraints on homogeneity and symmetry in the form of cross-equation restrictions on the parameters. In this way, the resulting coefficients can reflect the long-term steady structure of demand and competitiveness among transport modes. Moreover, such a specification allows the estimated model coefficients to be consistent with the theoretical background of the AI system (Andrikopoulos and Brox, 1997). This fact facilitates the rational long-range planning and evaluation of the operation of the transport system, and the formulation of appropriate policy recommendations.

By denoting as Q_i the quantity demanded for travel commodity i (e.g., number of trips or amount of petrol consumed) and noting that $w_i = P_i Q_i / X$ is a function of X, then the expenditure elasticity of demand can be calculated as follows:

$$e_i = \frac{\partial Q_i}{\partial X}\frac{X}{Q_i} = \frac{\partial (w_i X)}{\partial X}\frac{X}{P_i Q_i} = 1 + (\beta_i / w_i) \tag{5}$$

The above expenditure elasticity provides an indirect measure of the income elasticity, since it demonstrates the effect of only a part of the total expenditures (or income) of households on travel demand. In order to adjust the value of e_i such that a consistent measure of direct income elasticity is obtained, which distinguishes necessities and luxuries, the elasticity S of total travel expenditures X to an income (Inc) change is calculated by solving the following panel equation:

$$\log X = c_0 + c_1 \log Inc + b \log \mathbf{P} + \sum_k^K \delta_k G_k + \mathbf{L} + \theta_r S_r + \varepsilon \tag{6}$$

where c_0 is a constant term, c_1 is the coefficient of the logarithm of income Inc and b is the coefficient of the logarithm of Stone's price index. Then, the direct income elasticity e_{id} is given by the product:

$$e_{id} = e_i\, S = \left(\frac{\partial Q_i}{\partial X}\frac{X}{Q_i}\right)\left(\frac{\partial X}{\partial Inc}\frac{Inc}{X}\right) = \frac{\partial Q_i}{\partial Inc}\frac{Inc}{Q_i} \tag{7}$$

Furthermore, the present study estimates and compares two types of price elasticity, i.e., the uncompensated (Marshallian) and the compensated (Hicksian) own- and cross-price elasticities. The uncompensated price elasticities are based on maximizing utility under the budget constraint, while the compensated price elasticities are based on minimizing expenditures at a fixed utility level. Hence, the former comprises both substitution (transfer or diversion from or to other modes) and income (induction or generation of new demand) effects, due to changes in the total expenditures for the group of commodities of interest, i.e. total travel expenditures; the latter includes the substitution effect only. By representing the average (country-wide) inter-temporal budget share of mode i as $\overline{w}_i$, the uncompensated own- and cross-price elasticities are given through the following equations:

$$e_{ii}^{u} = \frac{\partial Q_i}{\partial P_i}\frac{P_i}{Q_i} = -1 + \left(\gamma_{ii}/\overline{w}_i\right) - \beta_i\,, \tag{8}$$

$$e_{ij}^{u} = \frac{\partial Q_i}{\partial P_j}\frac{P_j}{Q_i} = \left(\gamma_{ij}/\overline{w}_i\right) - \beta_i\left(\overline{w}_j/\overline{w}_i\right) \tag{9}$$

The compensated own- and cross-price elasticities are calculated as follows:

$$e_{ii}^{c} = e_{ii}^{u} + \overline{w}_i\left(1 + \beta_i/\overline{w}_i\right) = -1 + \left(\gamma_{ii}/\overline{w}_i\right) + \overline{w}_i \tag{10}$$

$$e_{ij}^{c} = e_{ij}^{u} + \overline{w}_j\left(1 + \beta_i/\overline{w}_i\right) = \left(\gamma_{ij}/\overline{w}_i\right) + \overline{w}_j \tag{11}$$

By comparing these two types of own- and cross-price elasticities, it can be observed that they differ by a positive amount equal to $\overline{w}_i\left(1+\beta_i/\overline{w}_i\right)$ and $\overline{w}_j\left(1+\beta_i/\overline{w}_i\right)$ in the compensated own- and cross-price elasticities respectively. Therefore, when the uncompensated price elasticities are negative and the expenditure (income) elasticities are positive, which implies that travel commodities are normal goods, the compensated price elasticities are less negative, i.e. less price elastic than the uncompensated ones. On the other hand, when the uncompensated price elasticities are positive and the travel commodities are normal goods, the compensated price elasticities are more positive, i.e. more price elastic than the uncompensated ones. Namely, the uncompensated cross-price elasticities are generally expected to demonstrate reduced substitutability and increased complementarity among transport modes, in comparison to the compensated elasticities. These differences are attributed to income effects and imply the generated (or induced) travel undertaken by users due to the increase of their purchasing power. Based on the specification of equation (1), the marginal effects of the additional determinants of demand can be calculated as follows:

$$m_{ik} = \delta_{ik} / \overline{w}_i \tag{12}$$

The values of price elasticities show the percentage change in the demand share for mode i given a unitary percentage change in the price of using mode j. The value of m_{ik} indicates the percentage change in the household budget share for mode i following an incremental change in variable G_k.

The formulation of the present panel demand system gives rise to a set of Least- Squares equations with Dummy Variables (LSDV) that leads to asymptotically efficient estimators, unlike Ordinary Least Squares (OLS) which do not guarantee efficient estimates of the system coefficients (Baltagi and Raj, 1992). The LSDV approach constitutes a two-way (fixed group and time effects) model, which can appropriately treat the panel effects of the current dataset and provide robust estimates. The estimator which is employed to solve the present demand system of LSDV equations refers to Zellner's iterative method of Seemingly Unrelated Regressions (SUR), which is commonly used for the solution of standard AI demand systems.

4. Description of consumption trends and study data

Transport expenses typically constitute a considerable portion of total household expenditures, together with other commodities such as health care, housing and food. Schafer (2000) reports that, in recent decades, some 10-15% of household final consumption expenditures in most OECD countries has been spent on transport. In the case of Greece, the share of total transport expenditures to total expenditures at household level showed a small decline from 10.85% in 1994 to 10.44% in 2004. The largest share of household transport expenditures relates to private motoring costs, which are mainly composed of the money spent for car usage and, especially, petrol consumption. Specifically, petrol expenses increased from 73.7% to 75.7% of total travel expenditures over the decade 1994-2004. Similarly, the household travel budget share for urban public transport services (mainly, bus and rail services in the Attica Region) increased from 7.8% to 8.3%. On the other hand, during the same period, the household travel budget shares for inter-urban public transport declined from 4.3% to 2.8% for bus (coach) and rail services, and from 1.8% to 1.6% for domestic airline services, while the expenditures for coast-wise sea transport remained steady at 3.4% of household total travel expenditures. The household travel budget share for taxi services also declined from 9.1% to 8.2% over the same period.

The data employed in the present demand system span the decade 1994-2004, since they have been obtained from the last three National Household Budget Surveys (HBS) of 1994, 1999 and 2004, conducted by the National Statistical Service of Greece (NSSG). The current dataset encompasses information corresponding to each of the 13 Regions (NUTS II level) of the country. Data obtained from previous waves of the HBS, before 1994, were based on a different regional aggregation system and, hence, could not be utilized for the purposes of the present analysis. The Greek HBS includes information about average monthly household travel (and non-travel) expenditures, based on a sample of about 2/1000 of the total population, using a multilayer stratified sampling methodology to ensure the representation power of the given sample at the NUTS II level.

The current study employs six dependent variables representing the demand for travel by different modes. In particular, the variable *gas* denotes the monthly average amount of money spent by households on vehicle petrol fuel purchase (category 1), which provides a key measure of the intensity of private vehicle usage. The variable *urb* expresses the household expenses for urban public transport, including the money spent purchasing fares and travel cards for the urban bus and railway (category 2). The variable *taxi* denotes the expenses for taxi services (category 3). The variables *air* and *sea* denote the expenditures for traveling by airplane (category 4) and coast-wise sea ferries (category 5). The travel expenses for coach and rail, which are expressed by the variable *land*, have been aggregated into a single category (category 6), due to the very small portion of the household budget allocated for using inter-city railway services (<1% of total travel expenditures).

The information about prices is based on the Consumer Price Indices (CPIs) corresponding to each of the six categories, as obtained from the NSSG. The CPI for the combined category of coach and rail has been calculated through the weighted combination of the CPIs corresponding to each individual category (these weights have also been provided by the NSSG). The information about the regional price variations of the public transport fares and taxi tariffs has been obtained from the Greek Ministry of Transport and Communications, while the information on the regional variation of petrol prices has been obtained from the Greek Ministry of Development. All monetary values used in the study, including household travel expenditures and income, have been deflated using the relevant CPI and expressed in 2005 constant prices in Euro. Table 1 presents the average monthly household expenditures by travel mode category over the whole country and the corresponding CPIs for the HBS years of the study.

Table 1. Greek average monthly travel expenditures by category and CPIs

		1994	1999	2004
gas	*expenses*	32.43	42.01	65.74
	CPI	64.18	71.91	91.53
urb	*expenses*	3.42	5.96	7.23
	CPI	50.51	74.46	98.10
taxi	*expenses*	4.00	6.83	7.11
	CPI	59.12	70.60	92.22
air	*expenses*	0.80	1.32	1.36
	CPI	56.72	65.27	94.47
sea	*expenses*	1.48	2.64	2.92
	CPI	45.88	71.79	96.95
land	*expenses*	1.91	2.17	2.46
	CPI	63.22	80.43	94.78

Sources: HBS 1994, 1999, 2004 and Annual CPI Reports, NSSG
Expenditures are expressed as current values in Euro.

In addition to the travel expenditures and prices, the present demand system is extended to include a set of additional explanatory variables concerning household and regional characteristics. Table 2 provides a description of these additional variables and their average values over the whole country for the HBS years of the study. The variable *eam* indicates the household employment status through the ratio of the economically active members to the total household size. The variable *gen* shows the gender composition of the households, in terms of the female to male ratio. The variable *child* shows the average number of children per household and it can provide a proxy of the age structure of families in each region. The variable *tert* indicates the portion of labor working in the tertiary production sector and it can roughly depict the impact of structural transformation processes in regional economies on travel demand shares.

Table 2. Description of the additional variables used in the model

Variable name	Description	1994	1999	2004
eam	Ratio of economically active members to total hh size	0.41	0.42	0.42
gen	Female to male ratio	1.07	1.10	1.07
child	Average no. of children per hh	0.49	0.42	0.33
tert	Portion of labour force in the tertiary production sector	0.55	0.57	0.61
deurb	De-urbanization index	1.42	1.37	0.79
cong	Congestion index	2.75	3.74	4.42

The variable *deurb*, referred to here as de-urbanization index, is expressed as the ratio of the number of households staying in a one- or two-story housing unit to those staying in a multi-unit housing (block of flats). This index can indicate the effect of economies of agglomeration caused by (de)urbanization trends in the regions. The variable *cong*, referred to here as congestion index, is expressed as the ratio of the total household vehicular stock (given by the product of the total number of households and the average number of cars per household) to the public road infrastructure stock (in terms of the road network length, in kilometers). This index reflects the impact of congestion costs, in terms of the net effect of total car ownership and road provision, on the demand share of different modes. Summing up, the present dataset includes 39 observations, i.e. 3-year observations over 13 regions, for five independent demand equations of transport modes, namely, car, urban public transport, taxi, airplane and sea ferry (excluding the coach and rail category, given the adding-up constraint); this constitutes a total of 195 observations.

5. Empirical results

5.1. Estimates of model parameters

This section presents the empirical results obtained from the model implementation and discusses the inferences which can be made in relation to the estimated coefficients and the resulting elasticities. Table 3 reports the estimates of the coefficients of the AI demand system and the relevant statistics. Moreover, the table indicates the coefficient of determination (R^2) of the independent demand equations, which ranges from 40% to 74%, and the associated standard errors. The results of the

Durbin-Watson (D-W) test statistics demonstrate that there is no problem of serial correlation in the demand equations, based on Durbin's *h*-statistic (see Johnston and DiNardo, 1997).

Table 3. Estimated coefficients of the demand system

	gas	*urban*	*taxi*	*air*	*sea*	*land*
α_i	9.88E-01**	7.66E-02	2.14E-01**	-1.15E-01**	-1.96E-01**	3.20E-02
γ_{i1}	2.70E-01**	1.94E-02	-3.39E-02	1.57E-03	-1.05E-01*	-1.53E-01**
γ_{i2}	1.94E-02	-7.29E-02**	4.64E-02	-3.41E-02**	6.11E-02*	-1.99E-02*
γ_{i3}	-3.39E-02	4.64E-02	4.15E-03	-6.48E-02**	-2.17E-02	6.99E-02*
γ_{i4}	1.57E-03	-3.41E-02**	-6.48E-02**	-9.58E-03	3.02E-02*	7.68E-02
γ_{i5}	-1.05E-01*	6.11E-02*	-2.17E-02	3.02E-02*	-1.03E-01**	1.38E-01**
γ_{i6}	-1.53E-01**	-1.99E-02*	6.99E-02*	7.68E-02	1.38E-01**	-1.12E-01**
β_i	-6.72E-02*	2.24E-02	6.57E-02**	-1.45E-02	-2.28E-02	1.65E-02
$\delta_{i,eam}$	3.29E-01*	-2.36E-01**	-2.46E-01**	1.78E-02	1.66E-01*	-2.98E-02
$\delta_{i,gen}$	-4.41E-02	-9.96E-02**	-6.35E-02*	6.35E-02**	8.09E-02**	6.39E-02**
$\delta_{i,child}$	-9.18E-05**	5.91E-05**	2.45E-05	-2.18E-05	4.27E-05**	8.05E-03
$\delta_{i,tert}$	-2.12E-01**	6.49E-02	-5.42E-03	4.17E-02	4.72E-02	6.29E-02**
$\delta_{i,deurb}$	-2.92E-03	-2.68E-03*	-2.04E-03	4.31E-05	3.33E-03**	4.26E-03
$\delta_{i,cong}$	-2.57E-01**	1.22E-01**	-8.18E-03	7.46E-02**	6.04E-02**	-1.26E-05
R^2	63.860	72.458	39.840	43.206	73.790	60.995
Std .error	0.046	0.024	0.028	0.023	0.023	0.020
D-W test	2.364	1.701	2.715	1.559	2.353	1.965

* indicates 0.05<*p*-value<0.1, ** indicates *p*-value<0.05, using the *t*-test statistics

Based on the statistical significance of the estimated β_i coefficients, in terms of the *t*-test statistics, it can be deduced that a change in real income (expenditures), $X/\mathbf{P}$, will considerably affect the demand share for petrol consumption and taxi usage, in contrast with the use of urban and inter-urban public transport modes, where the corresponding β_i coefficients are not found to be statistically significant. The direction (positive or negative) of the real income effect on the various travel commodity shares depends on the nature of these commodities. Specifically, an increase in the real income, other things being equal, will reduce (since β_i<0) the expenditure shares for petrol consumption and air and coast-wise sea transport services, and will increase (since β_i>0) the shares for all other transport services. Thus, the private vehicle (energy) use, airplanes and sea ferries can be characterized as necessities, and the usage of urban and inter-urban land (bus and rail) public transport services and taxis can be characterized as luxuries (also see subsection 5.2).

By and large, the results signify a moderate degree of price sensitivity of travel budget shares, based on the statistical significance of the estimated γ_{ij} coefficients. In terms of the own-price elasticities, the figures in Table 1 indicate that, with the exception of taxi and airline services, all the other γ_{ij} values are found to be statistically significant. Similarly, the majority of the γ_{ij} coefficients corresponding to the cross-price effects are found to be statistically significant. The degree of each cross-price effect on the budget shares depends on the nature of the travel commodities, namely, on whether they are complements or substitutes for each other (see subsection 5.2). In addition, inspection of the impact of additional factors on budget shares reveals that more than half of the estimated δ_{ik} coefficients are statistically significant at the conventional confidence levels. More specifically, each one of the independent demand equations is significantly affected by at least two and usually more than two of these additional factors. A discussion of the direction and magnitude of their estimated marginal effects is provided in subsection 5.2. Finally, the results (not shown in the tables)[1] demonstrate that both the time- and region-specific effects are statistically different from zero, based on the joint Wald tests, which provide theoretical justification of the use of the LSDV approach. In particular, the time-specific effects and most of the region-specific effects (excluding the local effects of East Macedonia and Thrace, Epirus, North Aegean and Peloponnesus) on the budget shares are found to be statistically significant at the conventional levels of confidence.

5.2. Estimates of elasticity values

The mean point elasticities obtained from the model parameter estimates are tested under the null hypotheses of zero and unit values, in order to determine whether the demand is perfectly inelastic ($e = 0$), relatively inelastic ($0 < e < 1$), unit elastic ($e = 1$) or relatively elastic ($e > 1$) in relation to changes in expenditures (income) and prices. Table 4 presents the estimates of indirect (expenditures) and direct income elasticities. The direct income elasticities are based on the estimation of the elasticity S of total expenditures to income, which was found to be equal to $S = 0.955$ and statistically non-significantly different from unity, i.e. it is a unitary elasticity. This outcome

[1] Available from the author upon request

implies that a given percentage change in income leads to a nearly equal percentage change in the total expenditures spent for travel. Therefore, no statistically significant differences are found between the indirect and direct income elasticities.

Table 4. The estimated indirect and direct income elasticities

	gas	*urban*	*taxi*	*air*	*sea*	*land*
indirect	0.908**†	1.259**†	1.692**	0.213	0.381	1.461**
direct	0.866**†	1.202**†	1.615**	0.203	0.363	1.395**

*(**) Elasticity significantly different from zero with 0.05<*p*-value<0.1 (*p*-value<0.05)
† Elasticity non-significantly different from unity with *p*-value<0.05

All travel commodities are found to be normal goods, since $e_i > 0$. The results show a clear distinction among necessity travel commodities, including travel by private vehicle, airplane and sea ferry (income elasticity $e_i < 1$) and luxury travel commodities, including travel by urban bus and rail, taxi, inter-urban rail and coach (income elasticity $e_i > 1$). Thus, the sensitivity of the quantity of travel demanded by users to changes in disposable income can vary significantly between different transport modes. The low (below unity) elasticity of the private road vehicle travel reflects the increased car dependence of consumers and it is within the range of other income elasticities found in the literature (Ingram and Liu, 1999; Goodwin et al., 2004; Graham and Glaister, 2004). On the other hand, the relatively low income elasticities of short-sea travel and, especially, air travel, in comparison to the results of other studies in the literature (see Gillen et al., 2002) can be attributed to the particular geographical features and the discontinuous network structure of the transport system in Greece. Such features are the mountainous countryside terrain and scattered island peripheries (Ionian Islands, North Aegean, South Aegean and Crete), which render both short-sea and air transport as indispensable modes of communication (Andrikopoulos and Terovitis, 1983).

Tables 5 and 6 present the estimates of the uncompensated (Marshallian) and compensated (Hicksian) price elasticities respectively. From the perspective of the inferences that can be made about the sign of the price elasticity estimates, most of the findings are reassuring to the theory. All uncompensated own-price elasticities are found to be negative, with most of them (i.e. those of private vehicle, urban public transport, short-sea transport and inter-urban surface public transport) being statistically significant. Similarly, all compensated own-price elasticities are found to be negative, except for that relating to private road vehicles, the estimated value for which is positive but statistically insignificant and close to zero. This result is consistent with the findings of empirical studies (Harding, 2001; Osula and Adebisi, 2001) showing the stability of vehicular travel expenditures relative to changes in fuel prices, through cutting back expenditure on other commodities. The other compensated own-price elasticity values, except for that corresponding to taxi usage, are found to be statistically significant.

Table 5. The uncompensated (Marshallian) price elasticities

	gas	*urban*	*taxi*	*air*	*sea*	*land*
gas	-0.561^{**}	0.035	-0.038	0.004	-0.141^{*}	-0.206^{*}
urban	0.037	-1.867^{**}	0.513	-0.400^{**}	0.699^{*}	-0.238
taxi	$-0.861^{\dagger}$	0.429	$-1.022^{\dagger}$	-0.695^{**}	-0.254	0.711^{*}
air	0.658	-1.778^{**}	-3.431^{**}	-1.504	1.661^{*}	4.181^{**}
sea	-2.391	1.711^{*}	-0.530	$0.830^{*\dagger}$	-3.771^{*}	3.770^{*}
land	-4.601^{*}	-0.596	1.909^{*}	2.136^{*}	3.843^{*}	-4.152^{*}

*(*) Elasticity significantly different from zero with 0.05<*p*-value<0.1 (*p*-value<0.05)
† Elasticity non-significantly different from -1 or 1 with *p*-value<0.05

Table 6. The compensated (Hicksian) price elasticities

	gas	*urban*	*taxi*	*air*	*sea*	*land*
gas	0.099	0.113^{*}	0.048	0.021	-0.107	-0.174^{**}
urban	$0.953^{\dagger}$	-1.759^{**}	0.633	-0.377^{**}	0.745^{*}	-0.195
taxi	0.370	0.575	$-0.861^{\dagger}$	-0.664^{**}	-0.192	0.772^{*}
air	$0.813^{\dagger}$	-1.759^{**}	-3.410^{**}	-1.500^{*}	1.668^{*}	4.189^{**}
sea	-2.114	1.744^{*}	-0.494	$0.837^{*\dagger}$	-3.757^{**}	3.784^{**}
land	-3.538^{**}	-0.470	2.048^{*}	2.163^{**}	3.897^{**}	-4.100^{**}

*(*) Elasticity significantly different from zero with 0.05<*p*-value<0.1 (*p*-value<0.05)
† Elasticity non-significantly different from -1 or 1 with *p*-value<0.05

In terms of the magnitude of price elasticity estimates, the values of uncompensated and compensated own-price elasticities are, more or less, of the same magnitude for all modes, with the exception of private vehicles. In particular, the consumption demand for public transport modes (i.e. urban public transport, inter-urban surface public transport, air and sea transport) is found to be price elastic (e>1). The own-price elasticities of taxi services are found to be non-significantly different from unity, i.e. they are unit elastic. The large difference between the uncompensated (-0.561) and compensated (0.099) own-price elasticities of private vehicle may reflect the wide range of both mandatory (e.g. commuting) and discretionary (e.g. leisure) trip purposes involved in using this transport mode.

The systemic methodological approach used here, in combination with the panel nature and low time frequency of the data, do not allow a reliable comparison of the price elasticities of travel consumption demand for different modes with those obtained from other studies, which mainly concern the amount of travel. However, the small own-price elasticity values of private vehicle use (or fuel consumption) are close to many of those found in the literature (Goodwin et al., 2004; Graham and Glaister, 2004). The relatively large price elasticity values estimated for some public transport modes, especially those of urban and inter-urban bus and rail, and sea ferry, can be attributed to the fact that demand tends to be more elastic in the long-run, as consumers often need time to adjust their spending patterns, e.g. through finding suitable substitutes, or even rearranging their habitual activity participation and location decisions.

As was expected from the theory (see Section 3), the uncompensated cross-price elasticities indicate reduced substitutability (degree of competitiveness) and increased complementarity among transport modes, in comparison to the compensated cross-price elasticities. In both cases, more than half of the cross-price elasticities are found to be statistically significant. Based on the uncompensated cross-price elasticity measures, statistically significant complementarity relationships, i.e. induction effects, are found from private vehicle transport to short-sea transport, and between private vehicle transport and inter-urban surface public transport, urban public transport and air transport, and taxi services and air transport. Non-significant complementarities are found between taxi services and private vehicle usage, taxi services and short-sea transport, and urban public transport and inter-urban surface public transport. On the other hand, statistically significant substitution relationships are found between urban public transport and short-sea transport, taxi services and inter-urban surface public transport, air transport and short-sea transport, air transport and inter-urban surface public transport, and short-sea transport and inter-urban surface public transport. Private vehicle and urban public transport, private vehicle and air transport, and taxi services and urban public transport are found to be statistically non-significant substitutes.

The compensated cross-price elasticity measures imply basically similar substitution-complementarity relationships among transport modes to those obtained from the uncompensated cross-price elasticities. Specifically, private vehicle transport and inter-urban surface public transport, urban public transport and air transport, and taxi services and air transport are found to be significant complements. Also, complementarities but without statistical significance are found between private vehicle and short-sea transport, urban public transport and inter-urban surface public transport, and taxi services and short-sea transport. Statistically significant substitutions (i.e. diversion effects) are found from private vehicle transport to urban public transport, and between urban public transport and short-sea transport, taxi services and inter-urban surface public transport, air transport and short-sea transport, air transport and inter-urban surface public transport, and short-sea transport and inter-urban surface public transport. Other diversion (or transfer) effects are found from urban public transport to private vehicle transport, and between private vehicle transport and taxi services, private vehicle and air transport, and urban public transport and taxi services.

The complementarity relationships demonstrate the usage of access services by urban public transport modes to airports, and coach and railway stations and vice versa. Also, they indicate the preference of airplane and sea ferry users for the taxi as an access mode. There are significant induction effects between private vehicle usage and sea ferry travel and, particularly, from coach and rail to private vehicle. Except for access provision, the complementarities between modes using shared infrastructure facilities, i.e. the road network, may be attributed to economies of scale from the demand side, i.e. network effects. Specifically, the increase of consumption demand for road travel by such vehicular modes as car, taxi and coach, causes the need for providing more supply (road capacity) for servicing it, which, in turn, leads to more road-based accessibility and increases demand for road travel in the long run (induced demand). On the other hand, substitution relationships are largely manifested between modes using separate infrastructure facilities. Specifically, there are service-based and destination-based substitutions among inter-urban public transport modes, including the surface modes (coach and rail), airplane and sea ferry. The positive cross-price elasticities between urban public transport and sea transport can be attributed to the destination- and activity-based substitution relationship between the two modes, since their usage is largely associated with different periods of the year (the vacation period for sea transport and the non-vacation period for urban public transport).

5.3. Marginal effects of additional factors

Table 7 presents the estimated marginal effects of the additional factors of demand shares and their statistical significance based on the null hypothesis of zero value. Most of the marginal effects on demand shares are found to be statistically significant. The increase of the proportion of economically active family members (*eam*) positively affects the demand share of private vehicle usage, and reduces the share of urban public transport.

Table 7. The estimated marginal effects of the additional determinants of demand

	gas	*urban*	*taxi*	*air*	*sea*	*land*
eam	0.452*	-2.740**	-2.596**	0.963	4.491*	-0.833
gen	-0.292**	0.752	-0.057	2.258	1.280	1.785
child	-0.353**	1.417**	-0.086	4.038**	1.640*	0.225
tert	-0.061	-1.155**	-0.669*	3.436**	2.194**	1.759**
deurb	-0.004	-0.031*	-0.021	0.002	0.090**	0.119**
Cong	-0.0001**	0.0007**	0.0003	-0.0012	0.0012**	-0.0004

* indicates 0.05<*p*-value<0.1, ** indicates *p*-value<0.05

On the other hand, the increase of the congestion index (*cong*), the fraction of female (*gen*) and the number of children (*child*) favorably influences the demand share of urban public transport and decreases the share of private vehicle usage. The de-urbanization trends (*deurb*) and the degree of occupational participation in the tertiary sector (*tert*) positively affect the share of inter-urban public transport modes, i.e. coach and rail, airplane and sea ferry, while they adversely influence (as shown by the negative sign) the demand share of private vehicle, taxi and urban public transport.

6. Policy implications

The above empirical results have several policy implications concerning the management of private road vehicle usage, the promotion of public transport demand and the development of intermodal transport services. First, short-term measures directly related to the monetary cost of private vehicle usage, such as fuel taxation and road pricing, are not expected to have a considerable impact on the budget share of private vehicle transport. The fact that private vehicle transport remains inelastic even when accounting for income effects suggests the need for considering long-range strategies as complementary measures, like coordinated transport and land-use policies and planning regulations. Such long-term strategies should also account for induced demand and network effects by other road-based transport services.

Subsidization policies implemented to reduce the fare of urban and inter-urban public transport services are likely to positively affect the demand share of these modes and, hence, the revenues of the corresponding transport firms, particularly those of sea ferry, coach and rail, which are the most price-elastic travel commodities. Moreover, integrated fare policies and increased interconnectivity and interoperability between the urban and inter-urban public transport systems, especially those of coach, rail and air transport, could induce demand for passenger travel by these specific modes.

The evolution of liberalization in the Greek short-sea passenger transport market since 2004, in combination with the deregulated air passenger transport market (since 1992), is likely to invoke significant inter-modal substitution effects. These effects may cause a reduction of the budget share of inter-urban surface public transport modes, due to the significant and large cross-price elasticities of *land* with *sea* and *air*. Furthermore, the consideration of additional socio-demographic and regional factors influencing the travel budget allocation of Greek households (other than price and income) can provide useful information for the analysis and forecasting of travel demand and the intermodal planning of transport systems.

7. Summary and conclusions

This study describes the development and implementation of an extended panel demand system for domestic travel in Greece over the period 1994-2004. The model builds on the analytically rigorous Almost Ideal Demand System to examine substitutions and complementarities amongst all available passenger transport modes. The proposed model can provide a theoretically sound mechanism for identifying complex relationships involved in the travel market, considering both temporal and spatial variability in demand. The results of the model estimation allow the classification of different travel commodities into: (a) luxuries and necessities, based on the (direct and indirect) income elasticities, (b) price elastic and inelastic, based on own-price elasticities, and (c) substitutes and complements between each other, based on the cross-price elasticities. Moreover, they help determine the effects of additional factors, other than income and prices, on the travel expenditure allocation decisions.

The results demonstrate the existence of travel commodities of different natures (i.e. necessities or luxuries) and significant substitution and complementarity relationships between passenger transport modes. These findings suggest the importance of considering all distinct travel commodities in analyzing competitiveness in the travel market, in comparison to current practices which focus on individual travel commodity markets separately from the others, or combined categories (e.g. of private and public transport) of such commodities. As has been expected from the theory, most relationships refer to substitutions rather than complementarities, even more so when income effects are excluded, i.e. on the basis of the compensated cross-price elasticities. The results of the study can provide useful insight into the design and evaluation of suitable policies to manage road travel demand, and promote the demand for public transport modes and the integrated use of them.

REFERENCES

Andrikopoulos, A.A. and Terovitis, T. 1983, "An abstract mode model: A cross-section and time-series investigation". *International Journal of Transport Economics*. 10 (3), pp. 563-576.

Andrikopoulos, A.A. and Brox, J.A. 1990, "Canadian inter-city passenger transport: A simultaneous equation approach". *International Journal of Transport Economics*. 17 (3), pp. 311-328.

Andrikopoulos, A.A. and Brox, J.A. 1997, *Demand Analysis: Theory and Practice*. North Waterloo Academic Press: Waterloo, Canada.

Asensio, J., Matas, A. and Raymond, J-L. 2003a, "Redistributive effects of subsidies to urban public transport in Spain". *Transport Reviews*. 23 (4), pp. 433-452.

Asensio, J., Matas, A. and Raymond, J-L. 2003b, "Petrol expenditure and redistributive effects of its taxation in Spain". *Transportation Research -Part A: Policy and Practice*. 37 (1), pp. 49-69.

Baltagi, B. and Raj, B. 1992, "A survey of recent theoretical developments in the econometrics of panel data". *Empirical Economics*. 17 (1), pp. 85- 109.

Givoni, M. and Banister, D. 2007, "Role of the railways in the future of air transport". *Transportation Planning and Technology*. 30 (1), pp. 95-112.

Bergantino, A.S. 1997, "Estimating Engel curves for transport expenditures: Evidence from UK household budget data". *International Journal of Transport Economics*. 24 (2), pp. 279-305.

Christensen, L., Jorgenson, D.W. and Lau, L.J. 1975, "Transcendental logarithmic utility functions". *American Economic Review*. 65 (3), pp. 367-383.

Deaton, A. and Muellbauer, J. 1980, *Economics and Consumer Behavior*. Cambridge University Press: New York, NY.

Denton, F.T., Mountain, D.C. and Spencer, B.G. 1999, "Age, trend, and cohort effects in a macro model of Canadian expenditure patterns". *Journal of Business & Economic Statistics*. 17 (4), pp. 430-443.

Fujii, E.T., Khaled, M. and Mak, J. 1985, "An Almost Ideal Demand System for visitor expenditures". *Journal of Transport Economics and Policy*. 19 (2), pp. 161-171.

Gaudry, M. 1998, “Key substitution-complementarity features of travel demand models, with reference to studies of high speed rail interactions with air services”. Centre de recherché sur les transports, Publication CRT-98-08, University of Montreal, Canada.

Gillen, D.W., Morrison W.G. and Stewart, C. 2002, *Air Travel Demand Elasticities: Concepts, Issues and Measurement*. Department of Finance, Ottawa, Ontario, Canada. Available at http://www.fin.gc.ca/activty/consult/airtrav_e.html.

Goodwin, P., Dargay, J. and Hanly, M. 2004, “Elasticities of road traffic and fuel consumption with respect to price and income: A review”. *Transport Reviews*. 24 (3), pp. 275-292.

Graham, D.J. and Glaister, S. 2004, “Road traffic demand elasticity estimates: A review”. *Transport Reviews*. 24 (3), pp. 261-274.

Harding, D. 2001, “Macroeconomic effects of petrol prices”. *Mercer-Melbourne Institute Quarterly Bulletin of Economic Trends*. 1.01, pp. 21-28.

Ingram, G.K. and Liu, Z. 1999, “Determinants of motorization and road provision”. *World Bank Policy Research Working Papers*. No. 2042, World Bank: Washington, D.C.

Johnston, J. and DiNardo, J. 1997, *Econometrics Methods*. 4th edition, McGraw-Hill: New York, NY.

KPMG (1997) *A Study of the VAT Regime and Competition in the Field of Passenger Transport*. Report prepared for the European Commission's Taxation and Customs Union Directorate-General, European Union: Brussels (http://ec.europa.eu/taxation_ customs/resources/documents/pass_tran_kpmg_final.pdf)

Mergos, G.J. and Donatos, G.S. 1989, “Consumer behaviour in Greece: An application of the Almost Ideal Demand System”. *Applied Economics*. 21 (7), pp. 983-993.

NCP (1999) *National Competition Policy Review of the Transport Operations (Passenger Transport) Act 1994*. Report prepared for Ministry for Transport and Main Roads, Queensland, Australia (http://taxi-reg.home.att.net/ncpReview.pdf)

Njegovan, N. 2006, “Elasticities of demand for leisure air travel: A system modelling approach”. *Journal of Air Transport Management*. 12 (1), pp. 33-39.

Nolan, A. 2003, "The determinants of urban households' transport decisions: A microeconometric study using Irish data". *International Journal of Transport Economics*. 30 (1), pp. 103-132.

Oladosu, G. 2003, "An Almost Ideal Demand System model of household vehicle fuel expenditure allocation in the United States". *Energy Journal*. 24 (1), pp. 1-21.

Osula, D.O.A. and Adebisi, O. 2001, "Testing the stability of travel expenditures in Nigeria". *Transportation Research – Part A*. 35 (4), pp. 269–287.

Oum, T.H. and Gillen, D.W. 1983, "The structure of intercity travel demands in Canada: Theory, tests and empirical results". *Transportation Research – Part B*. 17 (3), pp. 175-191.

Rolle, J-D. 1997, "Estimation of Swiss railway demand with computation of elasticities". *Transportation Research – Part E*. 33 (2), pp. 117-127.

Pollak, R.A. and Wales, T.J. 1978, "Estimation of complete demand systems from household budget data: the linear and quadratic expenditure systems". *American Economic Review*. 68 (3), pp. 348–359.

Pollak, R.A. and Wales, T.J. 1981, "Demographic variables in demand analysis". *Econometrica*. 49 (6), pp. 1533–1551.

Schafer, A. 2000, "Regularities in travel demand: an international perspective". *Journal of Transportation and Statistics*. 3 (3), pp. 1-31.

Stone, R. 1954, "Linear expenditure system and demand analysis: an application to the patterns of British demand". *Economic Journal*. 64 (255), pp. 511-527.

Theil, H. 1976, *Theory and Measurement of Consumer Demand*. North-Holland: Amsterdam, The Netherlands.

Tridimas, G. 2002, "The dependence of private consumer demand on public consumption expenditures: Theory and evidence". *Public Finance Review*. 30 (4), pp. 251-272.

IN THE SAME SERIES

No 93 Y. Panagopoulos, I. Reziti, and Ar. Spiliotis, “Monetary and Banking Policy Transmission through Interest Rates: An Empirical Application to the USA, Canada, U.K. and European Union”. Athens, 2007.

No 92 W. Kafouros and N. Vagionis, "Greek Foreign Trade with Five Balkan States During the Transition Period 1993-2000: Opportunities Exploited and Missed. Athens, 2007.

No 90 Y. Panagopoulos, "Some Further Evidence upon Testing Hysteresis in the Greek Phillips-type Aggregate Wage Equation". Athens, 2007.

No 89 N. Benos, “Education Policy, Growth and Welfare". Athens, 2007.

No 88 P. Baltzakis, "Privatization and Deregulation". Athens, 2006 (In Greek).

No 87 Y. Panagopoulos and I. Reziti, "The Price Transmission Mechanism in the Greek Food Market: An Empirical Approach". Athens, 2006.

No 86 P. I. Prodromídis, " Functional Economies or Administrative Units in Greece: What Difference Does It Make for Policy?" Athens, 2006. Published in: *Review of Urban & Regional Development Studies,* vol. 18.2, 2006, 144-164.

No 85 P. I. Prodromídis, "Another View on an Old Inflation: Environment and Policies in the Roman Empire up to Diocletian’s Price Edict". Athens, 2006.

No 84A E. Athanassiou, "Prospects of Household Borrowing in Greece and their Importance for Growth". Athens, 2006.

No 83 G. C. Kostelenos, "La Banque Nationale de Grèce et ses statistiques monétaires (1841-1940)". Athènes, 2006. Published in: *Mesurer la monnaie. Banques Centrales et construction de l’ autorité monétaire (XIX^e-XX^e siècle),* Paris: Edition Albin Michel, 2005, 69-86.

No 82 P. Baltzakis, "The Need for Industrial Policy and its Modern Form". Athens, 2006 (In Greek).

No 81 St. Karagiannis, "A Study of the Diachronic Evolution of the EU’s Structural Indicators Using Factorial Analysis". Athens, 2006.

No 80 I. Resiti, "An investigation into the relationship between producer, wholesale and retail prices of Greek agricultural products". Athens, 2005.

No 79 Y. Panagopoulos, A. Spiliotis, "An Empirical Approach to the Greek Money Supply". Athens, 2005.

No 78 Y. Panagopoulos, A. Spiliotis, "Testing Alternative Money Theories: A G7 Application". Athens, 2005.

No 77 I. A. Venetis, E. Emmanuilidi, "The fatness in equity Returns. The case of Athens Stock Exchange". Athens, 2005.

No 76 I. A. Venetis, I. Paya, D. A. Peel, "Do Real Exchange Rates “Mean Revert” to Productivity? A Nonlinear Approach". Athens, 2005.

No 75 C. N. Kanellopoulos, "Tax Evasion in Corporate Firms: Estimates from the Listed Firms in Athens Stock Exchange in 1990s". Athens, 2002 (In Greek).

No 74 N. Glytsos, "Dynamic Effects of Migrant Remittances on Growth: An Econometric Model with an Application to Mediterranean Countries". Athens, 2002. Published "The Contribution of Remittances to Growth: a Dynamic Approach and Empirical Analysis" in: *Journal of Economic Studies,* December 2005.

No 73 N. Glytsos, "A Model of Remittance Determination Applied to Middle East and North Africa Countries". Athens, 2002.

No 72 Th. Simos, "Forecasting Quarterly GDP Using a System of Stochastic Differential Equations". Athens, 2002.

No 71 C. N. Kanellopoulos, K. G. Mavromaras, "Male – Female Labour Market Participation and Wage Differentials in Greece". Athens, 2000. Published in: *Labour,* vol. 16, no. 4, 2002, 771-801.

No 70 St. Balfoussias, R. De Santis, "The Economic Impact of The Cap Reform on the Greek Economy: Quantifying the Effects of Inflexible Agricultural Structures". Athens, 1999.

No 69 M. Karamessini, O. Kaminioti, "Labour Market Segmentation in Greece: Historical Perspective and Recent Trends". Athens, 1999.

No 68 S. Djajic, S. Lahiri and P. Raimondos-Moller, "Logic of Aid in an Intertemporal Setting". Athens, 1997.

No 67 St. Makrydakis, "Sources of Macroecnomic Fluctuations in the Newly Industrialized Economies: A Common Trends Approach". Athens, 1997. Published in: *Asian Economic Journal,* vol. 11, no. 4, 1997, 361-383.

No 66 N. Christodoulakis, G. Petrakos, "Economic Developments in the Balkan Countries and the Role of Greece: From Bilateral Relations to the Challenge of Integration". Athens, 1997.

No 65 C. Kanellopoulos, "Pay Structure in Greece". Athens, 1997.

No 64 M. Chletsos, Chr. Kollias and G. Manolas, "Structural Economic Changes and their Impact on the Relationship Between Wages, Productivity and Labour Demand in Greece". Athens, 1997.

No 63 M. Chletsos, "Changes in Social Policy - Social Insurance, Restructuring the Labour Market and the Role of the State in Greece in the Period of European Integration". Athens, 1997.

No 62 M. Chletsos, "Government Spending and Growth in Greece 1958-1993: Some Prelimi-nary Empirical Results". Athens, 1997.

No 61 M. Karamessini, "Labour Flexibility and Segmentation of the Greek Labour Market in the Eighties: Sectoral Analysis and Typology". Athens, 1997.

No 60 Chr. Kollias and St. Makrydakis, "Is there a Greek-Turkish Arms Race?: Evidence from Co-integration and Causality Tests". Athens, 1997. Published in: *Defence and Peace Economics,* vol. 8, 1997, 355-379.

No 59 St. Makrydakis, "Testing the Intertemporal Approach to Current Account Determination: Evidence from Greece". Athens, 1996. Published in: *Empirical Economics,* vol. 24, no. 2, 1999, 183-209.

No 58 Chr. Kollias and St. Makrydakis, "The Causal Relationship Between Tax Revenues and Government Spending in Greece: 1950-1990". Athens, 1996. Published in: *The Cyprus Journal of Economics,* vol. 8, no. 2, 1995, 120-135.

No 57 Chr. Kollias and A. Refenes, "Modelling the Effects of No Defence Spending Reductions on Investment Using Neural Networks in the Case of Greece". Athens, 1996.

No 56 Th. Katsanevas, "The Evolution of Employment and Industrial Relations in Greece (from the Decade of 1970 up to the Present)". Athens, 1996 (In Greek).

No 55 D. Dogas, "Thoughts on the Appropriate Stabilization and Development Policy and the Role of the Bank of Greece in the Context of the Economic and Monetary Union (EMU)". Athens, 1996 (In Greek).

No 54 N. Glytsos, "Demographic Changes, Retirement, Job Creation and Labour Shortages in Greece: An Occupational and Regional Outlook". Athens, 1996. Published in: *Journal of Economic Studies,* vol. 26, no. 2-3, 1999, 130-158.

No 53 N. Glytsos, "Remitting Behavior of "Temporary" and "Permanent" Migrants: The Case of Greeks in Germany and Australia". Athens, 1996. Published in: *Labour,* vol. II, no. 3, 1997, 409-435.

No 52 V. Stavrinos, V. Droucopoulos, "Output Expectations Productivity Trends and Employment: The Case of Greek Manufacturing". Athens, 1996. Published in: *European Research Studies,* vol. 1, no. 2, 1998, 93-122.

No 51 A. Balfoussias, V. Stavrinos, "The Greek Military Sector and Macroeconomic Effects of Military Spending in Greece". Athens, 1996. Published in N.P. Gleditsch, O. Bjerkholt, A. Cappelen, R.P. Smith and J.P. Dunne: *In the Peace Dividend,* , Amsterdam: North-Holland, 1996, 191-214.

No 50 J. Henley, "Restructuring Large Scale State Enterprises in the Republics of Azerbaijan, Kazakhstan, the Kyrgyz Republic and Uzbekistan: The Challenge for Technical Assistance". Athens, 1995.

No 49 C. Kanellopoulos, G. Psacharopoulos, "Private Education Expenditure in a "Free Education" Country: The Case of Greece". Athens, 1995. Published in: *International Journal of Educational Development,* vol. 17, no. 1, 1997, 73-81.

No 48 G. Kouretas, L. Zarangas, "A Cointegration Analysis of the Official and Parallel Foreign Exchange Markets for Dollars in Greece". Athens, 1995. Published in: *International Journal of Finance and Economics*, vol. 3, 1998, 261-276.

No 47 St. Makrydakis, E. Tzavalis, A. Balfoussias, "Policy Regime Changes and the Long-Run Sustainability of Fiscal Policy: An Application to Greece". Athens, 1995. Published in: *Economic Modelling,* vol. 16 no. 1, 1999, 71-86.

No 46 N. Christodoulakis and S. Kalyvitis, "Likely Effects of CSF 1994-1999 on the Greek Economy: An ex Ante Assessment Using an Annual Four-Sector Macroeconometric Model". Athens, 1995.

No 45 St. Thomadakis, and V. Droucopoulos, "Dynamic Effects in Greek Manufacturing: The Changing Shares of SMEs, 1983-1990". Athens, 1995. Published in: *Review of Industrial Organization,* vol. 11, no. 1, 1996, 69-78.

No 44 P. Mourdoukoutas, "Japanese Investment in Greece". Athens, 1995 (In Greek).

No 43 V. Rapanos, "Economies of Scale and the Incidence of the Minimum Wage in the less Developed Countries". Athens, 1995. Published: "Minimum Wage and Income Distribution in the Harris-Todaro Model", in: *Journal of Economic Development*, 2005.

No 42 V. Rapanos, "Trade Unions and the Incidence of the Corporation Income Tax". Athens, 1995.

No 41 St. Balfoussias, "Cost and Productivity in Electricity Generation in Greece". Athens, 1995.

No 40 V. Rapanos, "The Effects of Environmental Taxes on Income Distribution". Athens, 1995. Published in: *European Journal of Political Economy,* 1995.

No 39 V. Rapanos, "Technical Change in a Model with Fair Wages and Unemployment". Athens, 1995. Published in: *International Economic Journal,* vol. 10, no. 4, 1996.

No 38 M. Panopoulou, "Greek Merchant Navy, Technological Change and Domestic Shipbuilding Industry from 1850 to 1914". Athens, 1995. Published in: *The Journal of Transport History,* vol. 16, no. 2, 159-178.

No 37 C. Vergopoulos, "Public Debt and its Effects". Athens, 1994 (In Greek).

No 36 C. Kanellopoulos, "Public-Private Wage Differentials in Greece". Athens, 1994.

No 35 Z. Georganta, K. Kotsis and Emm. Kounaris, "Measurement of Total Factor Productivity in the Manufacturing Sector of Greece 1980-1991". Athens, 1994.

No 34 E. Petrakis and A. Xepapadeas, "Environmental Consciousness and Moral Hazard in International Agreements to Protect the Environment". Athens, 1994. Published in: *Journal Public Economics,* vol. 60, 1996, 95-110.

No 33 C. Carabatsou-Pachaki, "The Quality Strategy: A Viable Alternative for Small Mediterranean Agricultures". Athens, 1994.

No 32 Z. Georganta, "Measurement Errors and the Indirect Effects of R & D on Productivity Growth: The U.S. Manufacturing Sector". Athens, 1993.

No 31 P. Paraskevaidis, "The Economic Function of Agricultural Cooperative Firms". Athens, 1993 (In Greek).

No 30 Z. Georganta, "Technical (In) Efficiency in the U.S. Manufacturing Sector, 1977-1982". Athens, 1993.

No 29 H. Dellas, "Stabilization Policy and Long Term Growth: Are they Related?" Athens, 1993.

No 28 Z. Georganta, "Accession in the EC and its Effect on Total Factor Productivity Growth of Greek Agriculture". Athens, 1993.

No 27 H. Dellas, "Recessions and Ability Discrimination". Athens, 1993.

No 26 Z. Georganta, "The Effect of a Free Market Price Mechanism on Total Factor Productivity: The Case of the Agricultural Crop Industry in Greece". Athens, 1993. Published in: *International Journal of Production Economics,* vol. 52, 1997, 55-71.

No 25 A. Gana, Th. Zervou and A. Kotsi, "Poverty in the Regions of Greece in the late 80's. Athens", 1993 (In Greek).

No 24 P. Paraskevaides, "Income Inequalities and Regional Distribution of the Labour Force Age Group 20-29". Athens, 1993 (In Greek).

No 23 C. Eberwein and Tr. Kollintzas, "A Dynamic Model of Bargaining in a Unionized Firm with Irreversible Investment". Athens, 1993. Published in: *Annales d' Economie et de Statistique,* vol. 37/38, 1995, 91-115.

No 22 P. Paraskevaides, "Evaluation of Regional Development Plans in the East Macedonia-Thrace's and Crete's Agricultural Sector". Athens, 1993 (In Greek).

No 21 P. Paraskevaides, "Regional Typology of Farms". Athens, 1993 (In Greek).

No 20 St. Balfoussias, "Demand for Electric Energy in the Presence of a two-block Declining Price Schedule". Athens, 1993.

No 19 St. Balfoussias, "Ordering Equilibria by Output or Technology in a Non-linear Pricing Context". Athens, 1993.

No 18 C. Carabatsou-Pachaki, "Rural Problems and Policy in Greece". Athens, 1993.

No 17 Cl. Efstratoglou, "Export Trading Companies: International Experience and the Case of Greece". Athens, 1992 (In Greek).

No 16 P. Paraskevaides, "Effective Protection, Domestic Resource Cost and Capital Structure of the Cattle Breeding Industry". Athens, 1992 (In Greek).

No 15 C. Carabatsou-Pachaki, "Reforming Common Agricultural Policy and Prospects for Greece". Athens, 1992 (In Greek).

No 14 C. Carabatsou-Pachaki, "Elaboration Principles/Evaluation Criteria for Regional Programmes". Athens, 1992 (In Greek).

No 13 G. Agapitos and P. Koutsouvelis, "The VAT Harmonization within EEC: Single Market and its Impacts on Greece's Private Consumption and Vat Revenue". Athens, 1992.

No 12 C. Kanellopoulos, "Incomes and Poverty of the Greek Elderly". Athens, 1992.

No 11 D. Maroulis, "Economic Analysis of the Macroeconomic Policy of Greece during the Period 1960-1990". Athens, 1992 (In Greek).

No 10 V. Rapanos, "Joint Production and Taxation". Athens, 1992. Published in: *Public Finance/Finances Publiques,* vol. 3, 1993.

No 9 V. Rapanos, "Technological Progress, Income Distribution and Unemployment in the less Developed Countries". Athens, 1992. Published in: *Greek Economic Review,* 1992.

No 8 N. Christodoulakis, "Certain Macroeconomic Consequences of the European Integration". Athens, 1992 (In Greek).

No 7 L. Athanassiou, "Distribution Output Prices and Expenditure". Athens, 1992.

No 6 J. Geanakoplos and H. Polemarchakis, "Observability and Constrained Optima". Athens, 1992.

No 5 N. Antonakis and D. Karavidas, "Defense Expenditure and Growth in LDCs - The Case of Greece, 1950-1985". Athens, 1990.

No 4 C. Kanellopoulos, *The Underground Economy in Greece:* "What Official Data Show". Athens (In Greek 1990 - In English 1992). Published in: *Greek Economic Review,* vol. 14, no.2, 1992, 215-236.

No 3 J. Dutta and H. Polemarchakis, "Credit Constraints and Investment Finance: No Evidence from Greece". Athens, 1990, in M. Monti (ed.), *Fiscal Policy, Economic Adjustment and Financial Markets, International Monetary Fund*, (1989).

No 2 L. Athanassiou, "Adjustments to the Gini Coefficient for Measuring Economic Inequality". Athens, 1990.

No 1 G. Alogoskoufis, "Competitiveness, Wage Rate Adjustment and Macroeconomic Policy in Greece". Athens, 1990 (In Greek). Published in: *Applied Economics,* vol. 29, 1997, 1023-1032.