RAILWAY INTER-CITY PASSENGER TRANSPORT IN SPAIN: A COINTEGRATION ANALYSIS

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Abstract

In this study, we present a theoretical model for the railway interurban passenger transport demands in Spain. Quarterly data are used for the 1980.I-1992.IV period, and several equations are estimated for the different modes of transport: railway (Talgo) and long distance (sleeping car, berths and seated transport).

Cointegration techniques, which are subject to a wide range of tests, are used to obtain short- and long-run equations. Moreover, we obtain the product, price and cross elasticities of each mode of transport. These estimations may be used to analyze the effects of transport tariffs on income changes, as well as to predict short- and long-run traffics.

INTRODUCTION

The analysis of passenger transport demand concerns companies that offer these services, regulation bodies of the public administration, and companies which supply transport equipment and material in general.

The initial models of passenger transport demand were the aggregate "modal split models". In these models, there has been an attempt to determine the number of journeys between two towns by a given set of modes of transport, taking into account the characteristics of the passengers. Some studies on modal split, such as Quandt and Baumol (1966), Boyer (1977), and Levin (1978), have been criticized by Oum (1979) and Winston (1985), among others, for the few variables used to account for the motivation of the user's behavior, and for using very simple linear patterns in their estimations.

Several models of aggregate passenger transport demand based on the user's behavior, have been carried out in order to improve the previous ones. The user's utility is optimized in these models, in line with the classic theory of consumer's behavior and demand. The work by Oum and Guillen (1979) about the user's behavior, is a typical example which analyses the passenger demand in Canada.

Some disaggregate research, based on the user's behavior, has also been done on passenger transport demand. The most significant research on these models is McFadden (1973, 1974), in which the user takes a discrete choice of some of the different modes of transport (railway, air, road transport, etc.) and it is assumed that the mode chosen optimizes the utility for the user. Since the use of a particular transport is random among the users, we obtain a probability function for the mode of transport chosen and, depending on the hypotheses carried out about the distribution of the errors, we obtain either a multinomial "logit", if errors are distributed according to the extreme value distribution method, or a multinomial "probit" model, if errors are normally distributed. Two studies which have used multinomial logit models to estimate the demand of inter-city passenger transport, are Grayson (1982), and Morrison and Winston (in Winston, 1985).

There is a rich literature on these models in order to study the spending structure and the aggregate demand of other goods such as food. However, they have not yet been applied to transport service demand. The reason for this may be the fact that there are no Consumption Surveys about transport service which are disaggregate enough. Moreover, we propose the modeling of the typical user's utility function as well as obtaining the maximum utility, subject to budget restrictions. Following, we have obtained the classic consumer behavior theory and making the conventional assumptions, and the Marshallian or ordinary demand functions of the user with respect to each transport service. Besides, according to Winston (1985), we may obtain the Marshallian demand functions from the user's indirect utility function by applying the Roy identity. Finally, we have obtain aggregate demand functions are obtained from the individual user's behavior and under the conventional assumptions.

Not much attention has been paid in Spain to passenger transport demand apart from city transport, which was analyzed by De Rus (1990), or the study of the petrol consumption "proxy" of road transport carried out by Peña (1978).

Income and price elasticities have been estimated by De Rus (1990) from a logarithmic model with a dynamic specification to obtain the possible lag adjustments of the demand, and Peña (1978) has used the Box-Jenkins methodology to predict petrol demand in Spain.

Spanish inter-city passenger transport was first studied in the "Elasticidad de la Demanda del Transporte Público de Viajeros" (Elasticity of the Passenger Public Transport Demand) by the Instituto de Estudios de Transportes y Comunicaciones (Institute of Transport and Communication Studies) (1978). Then, this was analyzed by Vázquez (1985) in a work carried out by the Secretaría General del Ministerio de Transportes (General Secretariat of the Ministry of Transport). In addition, other studies such as Inglada (1991), Coto-Millán and Sarabia (1994), and Coto-Millán Baños and Inglada (1995) have been carried out on this issue. The elasticities of the modes of transport in the main regions have been studied in the work by the IETC (1978) and in Vázquez (1985). Inglada (1992) studied price elasticities for monthly data between 1980.01 and 1988.12, with time series in which the residues were modeled with the Box-Jenkins techniques. Coto-Millán and Sarabia (1994) carried out uniequational models in order to estimate income elasticities, using the Industrial Production Index (IPI) and the Electric Power Consumption (CENER) for the 1980.01-1988.12 period. Monthly data were used in the estimations. In these works, the series were also modeled by the Box-Jenkins methodology.

This research offers a model according to the second proposal above, being based on a microeconomic analysis, which can be considered as classic, and its structure is very simple. Point number two presents the theoretical model for the Spanish passenger transport demand. Next point describes the data used. Point number four presents the estimations based on the different demands, and finally, the main conclusions are put forward in point number five.

THE MODEL

Assume a typical user whose preferences of goods verify the weak separability condition. Thus, the modeling of passenger transport service demand constitutes the second stage of a two-stage budget process. Firstly, the user's income falls into two big spending categories: passenger transport services and the remaining goods and services. Secondly, the user's income is assigned to the goods and services contained in each of these two categories. Therefore, the utility function of the representative user is as follows:

$$U = U(X_1, X_2, ...X_k; X_{k+1}, ..., X_n)$$

where vector $X_i = (X_1, X_2, ...X_k)$; with i= 1, 2,..., k represents the passenger transport services, vector $X_j = (X_{k+1}, ..., X_n)$; j= k+1,...n represents the goods and services except for those corresponding to passenger transport, and U represents a utility function which is continuous and differentiable, monotonous, increasing, and strictly quasi-concave.

The consumer equilibrium is reduced to:

$$\max U(X_i; X_j)$$

subject to: $p_i \cdot x_i + p_j \cdot x_j = Y$

where prices $P_i = (P_1, P_2, ..., P_k)$ and $P_j = (P_{k+1}, ..., P_n)$, and where Y represents the user's income level.

First order conditions allow to obtain the following typical user's Marshallian demands:

$$X_i = X_i(P_i, P_j, Y) \quad (1)$$

$$X_j = X_j(P_i, P_j, Y) \quad (2)$$

Of these individual demand functions, eqn (1) is interesting for us since it corresponds to passenger transport service.

Eqn (1) still presents some problems. Firstly, functions such as this one should be valid for any distribution of income among the different economic agents. If this were not the case, eqn (1) would provide as many values as distributions of income Y among the users were possible and therefore, such a function would not exist. In order to solve this problem, it can be assumed that all the users have the same level of income, with no further assumptions. Besides, it can be assumed that the income is distributed under a specific rule. Once this rule has been established, the integrability conditions are verified and the existence of the aggregate Marshallian demand functions is guaranteed, Varian (1992).

Eqn (1) is general enough to analyze the passenger transport service demands - Talgo and long-distance railway, air and road transport-, identifying the different subindexes for the amounts demanded in each service.

From 1980.I to 1992.IV, the passenger transport service in Spain has been provided under different regulation conditions. The government company RENFE has the monopoly of national railway transport in Spain . The prices of passenger transport services have been also regulated by the government during the period of this study. Under such regulation conditions and with the aim of preventing any problems which may arise from the supply-demand simultaneity, we assume that supply is exogenous in relation with prices and income and it is determined by the decisions of the government.

SPANISH DATA

The data on the series of long-distance passenger-km railway transport (VKF), passenger-km Talgo railway (VKT) have been obtained from the series provided by the Informes de Coyuntura del Ministerio de Transportes, Turismo y Comunicaciones.

The data on the series of long-distance railway prices-km (PF) and air transport tariffs (PA) have been obtained from the tariffs appearing in the monthly series of the Boletines Oficiales del Estado (Official State Reports), evaluated within the period in which each tariff was in force.

The data on the prices of premium petrol (PGAS, proxy of passenger road transport price) have been obtained from the Dirección General de Previsión y Coyuntura del Ministerio de Economía y Hacienda, as monthly data, also evaluated within the period in which each tariff was in force.

The data on the income variable have been obtained considering the Spanish quarterly PIB (GDP) as "proxy". The series used for the 1980.I-1989.IV period is that used by Mauleón (1989) and it was extended until 1992.IV from the series of the Contabilidad Nacional Española (Spanish National Accounting).

MARSHALLIAN DEMANDS OF RAILWAY INTERURBAN PASSENGER TRANSPORT: TALGO AND LONG DISTANCE.

We have estimated some equations from the specifications of eqn (2) adjusting the variables to each mode of transport. All variables headed by letter L are in natural logs and those headed by letter D are in differences, except for the dummy variables D81.I and D89.II, which will be properly defined later on in this research. The statistical "t" is presented within brackets under each coefficient.

To obtain the estimations, we have applied a cointegration approach, which has provided the most satisfactory results of the several approaches previously attempted Inglada (1991), Coto-Millán and Sarabia (1994). For more information about this subject, see Engle and Granger (1987), Johansen and Juselius (1990), and Osterwald-Lenum (1992).

Talgo Demand

The railway interurban passenger transport equation is segmented into Talgo, sleeping car, berths, seated transport and Electrotren. Talgo transport is the highest quality mode (apart from the high-speed train AVE, which started to operate in 1992 between Madrid and Seville), as regards service quality, the first and second-class Electrotren mode, is the best. Sleeping car, berths and seated transport are the lowest-quality modes and they usually fall into the so-called long-distance railway category, since they correspond to services usually offered all together in Fast and Express trains.

Long-run

We present below the long-run equilibrium cointegration equation estimated in logs of Talgo inter-city passenger transport demand:

$$LVKT_t = \underset{(3.68)}{-4.5} \underset{(3.73)}{-1.68\, LPF_t} \underset{(2.46)}{+0.37\, LPGAS_t} \underset{(6.36)}{+1.42\, LPIB_t}.$$

R^2 adjusted = 0.83
S.E. = 0.05
DW_1 = 1.91
DF = - 6.97
DW_2 = 2.00
Q(12)= 12.13
Estimation period: 1980.I-1992.IV; 52 observations; ordinary square minimum estimations.

Applying the Johansen methodology to a VAR with four lags and a restricted constant it is concluded that there is only one cointegration vector.

After normalization, the following cointegration relationship is obtained:

$$LVKT_t = -1.38 - 1.60\, LPF_t + 0.42\, LPGAS_t + 0.93\, LPIB_t.$$

In both estimated equations, the long-run elasticity of Talgo demand in relation with the PIB (GDP) is close to the unit (1.42-0.93). The estimated long-run elasticity is negative with values between 1.60 and 1.68, which suggests an important response of tariff demand that should be taken into account both for income and traffic predictions. The long-run cross elasticity has a variation interval of 0.37-0.42, which indicates the existence of gross substitution relationships between road inter-city passenger transport and Talgo railway (Varian, 1992).

Short-run

The non-linear joint estimation in only one of the stages of the above-mentioned long-run relationships and the difference variables provide the short-run relationships below:

$$DLKVT_t = \underset{(-7.04)}{-0.91} (LVKT_{t-1} \underset{(1.44)}{+4.34} \underset{(3.97)}{+1.87\, LPF_{t-1}} \underset{(-4.08)}{-0.49\, LPGAS_{t-1}} \underset{(-4.93)}{-1.48\, LPIB_{t-1}})$$

$$\underset{(-3.03)}{-0.24\, DLPF_{t-4}} \underset{(2.82)}{+0.79\, DLPGAS_t} \underset{(-2.62)}{-0.91\, LVKT_{t-4}}.$$

R^2 adjusted = 0.91
S.E. = 0.051
F = 71.70
DW = 1.93
Serial Correlation: Ljung-Box:
Q(1)= 0.03

Q(2)= 0.04
Q(3)= 0.55
Q(4)= 0.97
Residual Normality: Bera-Jarque: N(2) = 1.29
Heterocedasticity: ARCH (1-4) = 3.48
These validity tests are distributed as a χ^2 with its degrees of freedom shown within brackets.

Comparing both models, it is inferred that the coefficients do not undergo significant changes. Long-run coefficients are more accurately estimated with the two-stage method, since there is a smaller number of variables and more observations; however, the non-linear joint method allows us a better understanding of the short- and long-run inter-relationships. Moreover, as can be observed, elasticities do not have significant variations. In fact, the income long-run elasticity (with respect to the PIB (GDP)) is now 1.34, in contrast with the interval 1.42-0.93; the own-price elasticity of goods is negative with the value of 1.7, in contrast with the interval 1.60-1.68; and the cross elasticity is now 0.646, in contrast with the interval 0,37-0,42; these values being all properly adjusted. Therefore, the long-run income elasticity is unitary or slightly higher (or lower) than the unit, as it corresponds to normal goods. The long-run own-price elasticities of goods show an elastic demand in relation with prices, and cross elasticities suggest the existence of gross substitution relationships between Talgo and road passenger transport. It can be demonstrated that if both Talgo and road transport services are considered normal goods, the latter being a gross substitute for Talgo transport, there is a net substitution relationship between both transport services, since the cross substitution effect is positive.

Finally, gross and net substitution relationships between both road and Talgo inter-city passenger transport can be guaranteed.

Short-run elasticities present slight differences with respect to long-run elasticities. The reason for these differences is that users do not completely adjust their consumption within each term when there is a change of prices either in the service, or in other substitute transport services (road), and a change of income. In the short-run, the demand elasticity decreases with respect to the own-price elasticity of goods, getting closer to the unitary elasticity, and the cross elasticity becoming slightly more inelastic.

Long-Distance

Long-run

The long-run equilibrium cointegration equation of long-distance inter-city passenger transport demand (aggregate to: sleeping cars, berths and seated transport) is the following:

$$LVKF_t = \underset{(3.66)}{1.32} \; \underset{(-3.65)}{-0.95}\, LPF_t \; \underset{(3.83)}{+0.46}\, LPGAS_t \; \underset{(-2.39)}{-0.88}\, LPIB_t \; \underset{(-7.01)}{-0.14}\, DS89.II_t.$$

R^2 adjusted = 0.72
S.E. = 0.051
DW_1 = 1.90
ADF(2) = -4.68
DW2 = 1.97

A gradual variable has been included since 1990.I due to the change undergone since then by the methodology used to work out the long-distance series, so that the series obtained are more adjusted to lower values.

By applying the Johansen methodology to a VAR with three lags and a restricted constant, it is concluded that there is only one cointegration vector.

$$LVKF_t = 2.19 - 0.86\,LPF_t + 0.25\,LPGAS_t - 0.20\,DS89.II_t + 0.91 LPIB_t.$$

In both of the above-mentioned long-distance demand estimations, the long-run elasticities are not significant in relation with the PIB (GDP), and the own-price elasticities of goods are close to the unit with negative values between 0.86 and 0.95. In relation with road transport services, the long-run cross elasticities values range from 0.25 to 0.46. Therefore, we show the gross substitution relationships between road and railway interurban transport services. Since the sign of the cross-substitution effect is positive, the net-substitution relationship between both transport services is also positive.

Short-run

The non-linear joint estimation in a single stage of both long- and short-run equations (with all the difference variables) is as follows:

$$\underset{}{DLVKF_t} = \underset{(-7.38)}{-0.96\,(LVKF_{t-1}} \; \underset{(-0.53)}{-2.02} \; \underset{(2.37)}{+0.76\,LPF_{t-1}} \; \underset{(-3.72)}{-0.41\,LPGAS_{t-1}} \; \underset{(5.55)}{+0.10\,DS89.II_{t-1}}$$

$$\underset{(3.24)}{+0.77\,LPIB_{t-1})} \; \underset{(-1.8)}{-0.68\,DLPF_t} \; \underset{(-2.25)}{-0.10\,D81.I_t}.$$

R^2 adjusted = 0.66
S.E. = 0.039
F = 11.54
DW = 1.94
Serial correlation: Ljung-Box:
Q(1)= 0.14
Q(2)= 0.15
Q(3) = 1.54
Q(4) = 4.55
Residual Normality: Bera-Jarque: N(2) = 0.55
Heterocedasticity: ARCH (1-4) = 3.41

D.81.I and D89.II are dummy variables with values equal to 1 for these periods stated and the value 0 for the rest.

The D89.II dummy variables account for the effect of an agreement reached with workers in the second term of 1989, after several strikes which took place in the first term. The D81.I variable accounts once more for the workers' strikes which affected long-distance railway transport but did not affect Talgo railway.

When both models were compared again, the results obtained were similar. The estimation of the negative long-run own-price elasticity goods was 0.72 with respect to the values ranging from 0.95 to 0.86, and the cross elasticity was then 0.39 with respect to the values 0.25 and 0.46 previously obtained. There were also some effects of the strike which had not appeared before.

CONCLUSIONS

In this paper, we have presented a theoretical model of railway inter-city passenger transport demand. With quarterly aggregated Spanish data, we have specified equations of inter-city passenger transport demand for Talgo and long-distance railway (sleeping car, berths and seated transport) for the 1980.I and 1992.IV period.

Moreover, we have carried out different demand function estimations by using cointegration techniques, they being subject to a wide evaluation which allows us to check the adequacy of this method with respect to others used in earlier works such as Inglada (1992), and Coto-Millán and Sarabia (1994).

Each specific demand may require more detailed studies. However, having carried out the estimations, it is possible to meet conclusions as regards income elasticities, own-price elasticities and cross-elasticities such as the following:

- Long-run income elasticities are all positive and all the services are normal goods. Income elasticities are very close to the unit for Talgo and for long-distance railway.

- The own-price elasticities of goods increase parallel to the quality of the service, since they increase with tariffs, and present values higher than the unit for Talgo, close to the unit for long- distance railway transport.

- All cross elasticities present positive values and they are below the unit. Gross and net long- run substitution relationships between railway (Talgo and long-distance) and road inter-city passenger transport, are concluded.

These estimations can be useful for the analysis and predictions of the effects of tariff changing, as well as for traffic and short- and long- run income predictions.

ACKNOWLEDGMENTS

This research was partly financed by the PS95-0095 research project from the DGICYT (Dirección General de Investigación Científica y Técnica), a body from the Spanish Ministry of Science and Education.

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