BUSINESS TELEPHONE TRAFFIC DEMAND IN SPAIN:

AN ECONOMETRIC APPROACH*

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ABSTRACT

In this paper we use a theoretical model for the demand of telecommunication services to derive econometric models of the business demand for telephone traffic in Spain for the period 1980-1991. Using quaterly data, we estimate separate equations for the different types of toll traffic: local, long distance, national and international.
We use cointegration techniques to obtain long run and short run equations, both estimated separately in two steps and jointly, in one step. A battery of diagnostics is applied to each of the equations. Price and output elasticies agree with previous findings and could be used for analizing the revenue effects of changes in tariffs and medium term forecasting of traffic and revenues.

RESUMEN

En este trabajo se especifican y estiman modelos econométricos de demanda de tráfico telefónico en España por parte de empresas para el período 1980-1991. Usando datos trimestrales se estiman ecuaciones para los diferentes tipos de tráfico: local, interurbano, nacional e internacional.
Se utilizan técnicas de cointegración para obtener ecuaciones a corto y largo plazos, estimadas en dos pasos y, además, conjuntamente, en un paso. Las ecuaciones pasan una amplia batería de diagnósticos y las elasticidades estimadas pueden ser utilizadas para analizar los efectos de cambios en las tarifas sobre los ingresos, así como para previsiones a medio plazo de tráfico e ingresos.

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1. Introduction

Telephone demand has been the object of a large number of studies in recent years. Some pioneer studies are Artle and Averous(1973), Squire(1974), Rohlfs(1974) and Von Rabenau and Stahl(1974). Taylor(1993) presents a survey and critique of this literature.

It is useful to distinguish between access demand (demand for telephone lines) and usage demand (demand for telephone traffic). Access demand has received considerable attention in Spain: Treadway(1974), Martín(1985), Barroso(1985), Hernández(1988) and Mauleón(1991). Meanwhile, usage demand has received less attention. Studies on usage demand are Treadway(1974), Bader(1986), and Garín(1993). The latter estimates a model of national toll traffic demand, using annual panel data for all 50 provinces for the period 1985-1989 and Pérez(1993) wich estimates models of aggregate residential toll traffic demand for different lengths of haul, using quarterly time series for the period 1980-1990.

In this paper we present econometric models of the demand for local, long distance, national, and international toll traffic by the business sector. We use aggregate quarterly time series for the period 1980-1991. The rest of the paper is organized as follows, in section 2 we present a theoretical model of the business demand for telephone traffic. In section 3 we describe the data, in section 4 we present the estimated equations and section 5 contains the main conclusions.

2. Business demand for telephone services.

The basic reason for the use of telephone services by firms, as well as by the residential sector is to save communication costs. However, the demand for telephone traffic by firms presents characteristics which require specific analysis, based on the optimization problem of a firm. This differs from the utility maximization framework used in the analysis of individual residential consumer demand.

Let q be an Ix1 vector of quantities of telephone services in a given period of time, and π a 1xI vector of prices of telephone services, then the cost of use of the telephone service for a given period of time is πq. Let t be the number of trunk lines installed in a given firm and y a Jx1 vector of products and inputs of the firm with an associated price vector p of dimension 1xJ. Let N be the total number of lines of the telephone system.

We can use a production function that synthesises the organization and technology of the firm

$$f(t, N, q, y) = 0 \qquad [1]$$

in this case the presence of N in the production function is justified by the external economies of access and use derived from the subscription to the telephone network, and the justification would be similar to the one given in the case of residential subscribers by Artle and Averous(1973).

When choosing the optimal vector q of telephone services, the firm takes as given the number of installed lines, as well as the production function. Under general conditions, the optimization problem faced by the firm can be solved and a set of demands for telephone services can be obtained

$$q_i = q_i\,(t, N, p, \pi, y) \qquad i = 1, \ldots, I. \qquad [2]$$

It can be shown that under general conditions, telephone demands are homogeneous of degree zero in the prices of all products and inputs, including telephone tariffs. Equations [2] can be used to estimate the demands for telephone services by a firm, conditional on the number of trunk lines installed. Firms vary a great deal from one another in terms of their productive structure, and this requires, when possible, a disaggregation in the study of the demand by different business sectors; see Curien and Gensollen(1989) and Taylor(1993).

When only aggregate data is available, as in the present study, equations [2] suggest that the aggregate demand for telephone services by the business sector could be represented by

$$Q_i = Q_i(T, N, p, \pi, Y) \qquad i = 1, \ldots, I. \qquad [3]$$

where T is the total number of trunk lines in service in the business sector, and Y is a measure of the aggregate output of the business sector. For each service, the partial derivative with respect to its own price should be negative and the cross price elasticities could be positive or negative depending on whether they are substitute or complementary services or inputs. The partial derivatives with respect to the number of business lines T, total lines, N and output, Y, should be positive.

The framework we have presented here is general enough so that it can be adapted to analyze the business demand for local, long distance, national and international toll calls.

3. Spanish Data

In the period 1980-1991, the telephone service was provided for in Spain in a monopolistic regime by Telefónica de España S.A., a private company. The terms of provision of the service were regulated by the government, and the tariffs were revised around april of each year.

Spanish telephone data was obtained from Telefónica de España. We were provided with monthly data on total consumption of homogeneous[1] pulses, disaggregated by types of subscribers: residential and business. The data on business demand is further disaggregated in local toll, long distance toll and international toll traffic. We have also considered national toll traffic, which consists of the sum of local toll plus long distance toll[2].

In the period considered, all local calling was toll calling; local toll was considered very inexpensive, while long distance and international calling were highly priced. We constructed nominal price indexes for each length of haul based on the public rates and using a fixed average call for each of the lengths: 257 seconds, 214 seconds and 235 seconds for local, long distance and international calls respectively. Quarterly gross internal product was obtained extending the data in Mauleón(1989). Imports, exports and CPI were obtained from Banco de España(1992). Monthly variables were converted to quarterly data by adding them up in the case of flows and by averaging in the case of stocks. All nominal variables were deflated by the CPI.

In 1991, revenue derived from telephone traffic was 70.48% of the operating revenues of Telefónica. Business traffic represented 61.92% of total traffic. Long distance traffic represented 51.34% of business traffic, whereas local and international traffic were 23.30% and 25.35% respectively. Business traffic increases, in logarithmic rates, by 94% between 1980 and 1991. Its components, however, present very different rates of growth. International traffic grew by 156%, whereas local toll and long distance grew by 88% and 76% respectively. National traffic experienced an increase of 80% over this period.

Telephone monthly data was analyzed using ARIMA models, and outliers were detected. We confronted the persons that elaborated the data with these outliers and they argued that they were coincidental with changes in the way the data was recorded. The figures for outlier months were redistributed with contiguous months, according to this information, while keeping the totals unaltered.

4. Equations of business demand for local, long distance, national and international traffic.

We present equations that have been derived from [3], adapting them to the available data and type of traffic. A more detailed account of empirical models can be found in Taylor (1993). The equations were estimated using quaterly data. All variables except the price index are in natural logs. The standard deviation is below each coefficient, in parenthesis. We employ cointegration techniques to model long and short run relationships. For each type of traffic, we estimate two-steps and one step equations; see Engle and Granger (1987) and Johansen (1988). A battery of diagnostics is applied to each of the one step equations, and presented in Appendixes 1 and 2. We place more emphasis in the analysis of equations estimated in one step because the t ratios are correct and can be interpreted directly, whereas this is not the case for two steps estimates.

Business local traffic:

The variables of the long run relationship are:

lurblin: log of local homogeneous pulses per business line.
d3: dummy variable for the third quarter.
lpib: log of gross domestic product.
indcmu: price index of local traffic.
mce: residuals from the long run equation, it will be the error correction mechanism in the short run equation.

$$\underset{}{lurblin_t} = \underset{(0.46)}{-11.11} - \underset{(0.01)}{0.12\, d3_t} + \underset{(0.05)}{1.38\, lpib_t} - \underset{(0.0014)}{0.0062\, indcmu_t} + mce_t \qquad [4]$$

$R^2 = 0.96$	$F = 320.5$
$\hat{\sigma} = 0.04$	$DW = 1.32$
$ADF = -4.34(DW = 2.02)$	$T = 48$

Sample period; 1980:I-1991.IV. The first DW statistic refers to equation [4] and the second is from the equation used to compute the ADF statistic.

From this model, we obtain a long run elasticity of traffic per line to output of 1.38, and a

price elasticity of -0.17 (0.04) in the average of the price index, with a maximum of -0.24 and a minimum of -0.14.

Based on this long run relationship, we model the short run. The definition of the variables is as follows:

dlurblin: rate of growth of local traffic per business line.
dindcmu: change of local price index.
dlpib: rate of growth of gross domestic product.

$$dlurblin_t = \underset{(0.0030)}{-0.0067\, dindcmu_{t-1}} + \underset{(0.40)}{0.86\, dlpib_t} + \underset{(0.07)}{0.80\, dlurblin_{t-4}} - \underset{(0.19)}{0.44\, mce_{t-1}} + \hat{\epsilon}_t \qquad [5]$$

$R^2 = 0.86$	$F = 78.45$
$\hat{\sigma} = 0.04$	$DW = 2.02$
$ADF = -6.91(DW = 1.91)$	$T = 43$

Sample period; 81:I to 91:IV. In this equation we obtain a short run output elasticity of 0.86 (0.40) and a short run price elasticity of -0.18 (0.08) in the average of the price index, with a maximum of -0.25 and a minimum of -0.15. The price elasticity in the average coincides with the estimate if we impose a constant price elasticity. The estimates of the other coefficients are not affected by the functional form chosen for the price elasticity.

The joint nonlinear estimation of the previous two equations gives the following results:

$$dlurblin_t = \underset{(0.0042)}{-0.0068\, dindcmu_{t-1}} + \underset{(0.42)}{1.02\, dlpib_t} + \underset{(0.10)}{0.60\, dlurblin_{t-4}} - \underset{(0.14)}{0.48}\, (lurblin_{t-1} + \underset{(1.67)}{10.41} - \underset{(0.19)}{1.29\, lpib_{t-1}} + \underset{(0.0054)}{0.0063\, indcmu_{t-1}}) + \hat{\epsilon}_t \qquad [6]$$

$R^2 = 0.88$	$F = 44$
$\hat{\sigma} = 0.04$	$DW = 1.99$
$ADF = -6.79(DW = 1.91)$	$T = 43$

Sample period; 81:I to 91:IV. The price elasticities derived from equation [6] are presented in the next table.

	Average(s.d)	Maximum	Minimum
Short run	-0.19(0.12)	-0.26	-0.15
Long run	-0.17(0.15)	-0.24	-0.14

This estimation is robust to the choice of initial conditions. Estimated parameters are of the same order as in the two steps estimation. This equation passes a battery of diagnostics which are presented in Appendixes 1 and 2. This equation obtains a unit long run elasticity to production and a small (-0.19) and marginally significant long run price elasticity. Both results are in line with what can be expected for a hard-to-substitute service which is more influenced by the level of production than by its own price. Moreover, the tariff is only a small part of the total cost of a local call. The opportunity cost of the time spent in the phone is the most important component of the total cost.

A more detailed study of local demand would require data on minutes of conversation as well as number of messages, which are not currently available.

Business long distance traffic:

The variables of the long run equation are:

lirblin: log of long distance homogeneous pulses per business line.
indcmiu: price index of long distance traffic.

$$lirblin_t = \underset{(0.87)}{-4.23} \underset{(0.01)}{-0.15\, d3_t} + \underset{(0.09)}{0.68\, lpib_t} - \underset{(0.00013)}{0.00034\, indcmiu_t} + mce_t \quad [7]$$

$R^2 = 0.90$ $\quad F = 139.8$
$\hat{\sigma} = 0.04$ $\quad DW = 1.36$
$ADF = -4.43(DW = 1.95)$ $\quad T = 48$

Sample period; 1980:I-1991:IV. The long run elasticity to output is 0.68, and the long run price elasticity is -0.26 (0.10) in the average of the price index, with a maximum of -0.30 and a minimum of -0.22.

Conditional on this equation we obtain the following short run relationship:

dlirblin: rate of growth of long distance traffic per business line.
dindcmiu: change of long distance price index.

d: dummy variable equal to 1 in 90:II, -1 in 91:II and 0 otherwise.

$$dlirblin_t = \underset{(0.00023)}{-0.00038\, dindcmiu_{t-1}} + \underset{(0.38)}{0.78\, dlpib_t} + \underset{(0.06)}{0.85\, dlirblin_{t-4}} - \underset{(0.19)}{0.49\, mce_{t-1}} - \underset{(0.03)}{0.10\, d_t} + \hat{\epsilon}_t \quad [8]$$

$R^2 = 0.91$ $\quad F = 91.48$
$\hat{\sigma} = 0.04$ $\quad DW = 2.25$
$ADF = -7.89(DW = 1.82)$ $\quad T = 43$

Sample period; 81:II to 91:IV. Here the short run price elasticity is -0.29 (0.17) in the average, -0.33 in the maximum and -0.24 in the minimum.

The joint estimation of equations [7] and [8] is:

$$dlirblin_t = \underset{(0.00025)}{-0.00047\, dindcmiu_{t-1}} + \underset{(0.44)}{0.77\, dlpib_t} + \underset{(0.09)}{0.68\, dlirblin_{t-4}} - \underset{(0.13)}{0.37}\, (lirblin_{t-1} + \underset{(2.84)}{2.43} - \underset{(0.30)}{0.46\, lpib_{t-1}} + \underset{(0.00044)}{0.00045\, indcmiu_{t-1}} + \underset{(0.03)}{0.10\, d_t}) + \hat{\epsilon}_t \quad [9]$$

$R^2 = 0.91$ $\quad F = 50.6$
$\hat{\sigma} = 0.04$ $\quad DW = 2.11$
$ADF = -7.36(DW = 1.88)$ $\quad T = 43$

Sample period; 81:II-91:IV. In the next table we can see the price index elasticity derived from the last equation:

	Average(s.d.)	Maximum	Minimum
Short run	-0.36(0.19)	-0.42	-0.31
Long run	-0.34(0.34)	-0.40	-0.29

The estimation is robust to the choice of initial conditions, and the estimated parameters are similar to the ones in the two steps estimation. Diagnostics are presented in Appendixes 1 and 2. From these equations we obtain long run price elasticities that vary between -0.4 and -0.2, which are in the same range of the estimates obtained for other countries, and slightly smaller in absolute value than the ones obtained by Pérez (1993) for residential customers.

Point elasticities to production vary from 0.68 to 0.77, which are again lower than those of Pérez (1993) for residential customers, as can be expected. It would be useful to have the minutes of conversation and the number of messages.

Business national traffic:

National traffic is the sum of the local and long distance traffics. For national traffic, the models are similar to the ones obtained for long distance traffic. The long run equation is:

lnaclin: log of national homogeneous pulses per business line.

$$lnaclin_t = \underset{(0.41)}{-6.65} \underset{(0.01)}{- 0.14\, d3_t} + \underset{(0.05)}{0.99\, lpib_t} - \underset{(0.0013)}{0.0046\, indcmu_t} + mce_t \qquad [10]$$

$R^2 = 0.94$ $F = 244.6$
$\hat{\sigma} = 0.03$ $DW = 1.61$
$ADF = -5.55 (DW = 1.91)$ $T = 48$

Sample period; 80:I-91:IV. In this equation, we use the local price index because we obtain better results than any combination using the long distance price index. The general shape of the two indexes is very similar. From this equation we derived a price elasticity of -0.13(.03) in the average of the price index, -0.18 in the maximum and -0.10 in the minimum.

We model the short run conditional on [10] with the next equation:

dlnaclin: rate of growth of national traffic per business line.

$$dlnacblin_t = \underset{(0.0026)}{-0.0073\, dindcmu_{t-1}} + \underset{(0.34)}{0.94\, dlpib_t} + \underset{(0.05)}{0.83\, dlnaclin_{t-4}} - \underset{(0.21)}{0.57\, mce_{t-1}} + \hat{\epsilon}_t \qquad [11]$$

$R^2 = 0.91$ $F = 125.17$
$\hat{\sigma} = 0.04$ $DW = 2.47$
$ADF = -8.90 (DW = 1.96)$ $T = 43$

Sample period; 81:I to 91:IV. In the short run, in a two steps estimation, we obtain a price elasticity of -0.20(0.07) in the average, -0.28 in the maximum and -0.16 in the minimum of the price index.

We have the following one step estimation for the national case:

$$dlnaclin_t = \underset{(0.0038)}{-0.0087\, dindcmu_{t-1}} + \underset{(0.37)}{0.97\, dlpib_t} + \underset{(0.08)}{0.63\, dlnaclin_{t-4}} - \underset{(0.14)}{0.44}\,(lnaclin_{t-1} + \underset{(1.62)}{6.37}$$
$$- \underset{(0.18)}{0.95\, lpib_{t-1}} + \underset{(0.0054)}{0.0036\, indcmu_{t-1}}) + \hat{\epsilon}_t \qquad [12]$$

$R^2 = 0.92$ $F = 69$
$\hat{\sigma} = 0.04$ $DW = 2.36$
$ADF = -6.57 (DW = 2.13)$ $T = 43$

Sample period; 81:I to 91:IV. Furthermore, we have the following price elasticities:

	Average(s.d.)	Maximum	Minimum
Short run	-0.24(0.10)	-0.33	-0.19
Long run	-0.10(0.14)	-0.15	-0.08

Like in the other cases, this estimation is robust to initial conditions, and the estimated parameters are similar to the values of the two steps estimation. For national traffic, we obtain unit long run elasticities to production, and long run price elasticities that vary between -0.18 and -0.08. These values are lower in absolute value than expected, since both its components are more elastic than the aggregate. This result can be attributed to aggregation and underscores the need for the modelization of each of the components.[3] Diagnostics are presented in Appendixes 1 and 2.

Business international traffic:

The long run equation is:
liallin: log of international homogeneous pulses per business line.
llineas: log of number of business lines.
lminusa: log of minutes of conversation from USA to Spain.
lentrada: log of number of nights spent by foreign nationals in Spanish hotels.

$$linal_t = \underset{(1.50)}{-14.50} - \underset{(0.16)}{0.60\, llineas_t} + \underset{(0.33)}{1.35\, lpib_t} + \underset{(0.04)}{0.41\, lminusa_t}$$
$$+ \underset{(0.01)}{0.18\, lentrada_t} + mce_t \qquad [13]$$

$R^2 = 0.98$ $\qquad F = 680.1$

$\hat{\sigma} = 0.05$ $\qquad DW = 2.37$

$ADF = -3.41 (DW = 1.69)$ $\qquad T = 48$

Sample period; 80:I-91:IV. As can be seen, in this equation we do not obtain a significant long run price effect. The interpretation of the minus sign of llineas is that as the number of business lines increases, international traffic per business line decreases. That gives us a long run elasticity of international demand to business lines of 0.4. We model the short run conditional on [13] with the next equation:

dliallin: rate of growth of international traffic per business line.
dindcmia: international price index, considering the cost of european calls.
dlentraa: rate of growth of number of nights spent by foreign nationals in spanish hotels.

$$\underset{}{dliallin_t} = \underset{(0.25)}{0.97}\, dlpib_t - \underset{(0.000038)}{0.000095}\, dindcmia_{t-3} + \underset{(0.02)}{0.09}\, dlentraa + \underset{(0.09)}{0.43}\, dliallin_{t-4}$$

$$- \underset{(0.12)}{0.53}\, mce_{t-1} + \hat{\epsilon}_t \qquad [14]$$

$R^2 = 0.94$ $\qquad F = 152.2$

$\hat{\sigma} = 0.03$ $\qquad DW = 1.85$

$ADF = -6.05 (DW = 1.77)$ $\qquad T = 43$

Sample period; 1981:II-1991:IV. In the short run, in a two steps estimation, we obtain a price elasticity of -0.28(0.11) on the average, -0.39 in the maximum and -0.18 in the minimum. This elasticity refers to a price index with three lags.

The joint nonlinear estimation of equations [13] and [14] gives the following results:

$$dliallin_t = \underset{(0.31)}{0.81}\, dlpib_t - \underset{(0.000041)}{0.000077}\, dindcmia_{t-3} + \underset{(0.02)}{0.13}\, dlentraa_t + \underset{(0.11)}{0.28}\, dliallin_{t-4} - \underset{(0.13)}{0.54}\, (liallin_{t-1}$$

$$+ \underset{(2.09)}{15.15} + \underset{(0.20)}{0.61}\, llineas_{t-1} - \underset{(0.48)}{1.38}\, lpib_{t-1} - \underset{(0.06)}{0.39}\, lminusa_{t-1} - \underset{(0.03)}{0.25}\, lentrada_{t-1}) + \hat{\epsilon}_t \qquad [15]$$

$R^2 = 0.95$ $\qquad F = 69.7$

$\hat{\sigma} = 0.03$ $\qquad DW = 2.05$

$ADF = -7.76 (DW = 1.88)$ $\qquad T = 43$

Sample period; 1981:II-1991:IV. The diagnostics of this equation are presented in Appendix 1. In this equation we obtain a short run price elasticity of -0.22(0.12) on the average, -0.31 in the maximum and -0.15 in the minimum. We expect the international demand to be more price elastic than local and long distance demands. However, we expected it to be less price elastic than the corresponding residential demand, as is usually the case for business demands.

With the data that we have available we haven't been able to estimate a long run price elasticity. Our interpretation is that international demand is the sum of many heterogeneous demands and the appropiate framework of analysis would be to disaggregate by countries and use a panel data framework.

The long run production elasticity estimates of 1.35-1.38 are in line with what can be expected for international demand. If we use the price index of the calls to the USA, we obtain similar results. If we substitute the minutes of conversation from the USA by the minutes of conversation from Europe the results are essentially the same. In Table 1 we synthesize the point estimates of the previous equations for easy reference.

Table 1. Price and income Elasticities of Business Demands for different lengths of haul.

Variables	Long Run		Short Run	
	Price (on the average)	Production	Price (on the average)	Production
One Step				
Local	-0.17 (0.15)	1.29 (0.19)	-0.19 (0.12)	1.02 (0.42)
Long Distance	-0.34 (0.34)	0.46 (0.30)	-0.36 (0.19)	0.77 (0.44)
National	-0.10 (0.14)	0.95 (0.18)	-0.24 (0.10)	0.97 (0.37)
International		1.38 (0.48)	-0.22 (0.12)	0.81 (0.31)
Two Steps				
Local	-0.17 (0.04)	1.38 (0.05)	-0.18 (0.08)	0.86 (0.40)
Long Distance	-0.26 (0.10)	0.68 (0.09)	-0.29 (0.17)	0.78 (0.38)
National	-0.13 (0.03)	0.99 (0.05)	-0.20 (0.07)	0.94 (0.34)
International		1.35 (0.33)	-0.28 (0.11)	0.97 (0.25)

Standard deviations are in parenthesis.

5. Conclusions and suggestions for further research.

In this study, we use a theoretical model for the demand of telephone traffic by firms, to derive empirical demands for the different types of telephone traffic in Spain. Using monthly figures from Spain for the period 1980.I-1991.IV, we analyze the data to detect and correct outliers caused by changes in the recording of the amount of traffic, and aggregate them in to a quarterly level. Based on published tariffs and the average duration of each type of call, we construct price indexes for each of the distances considered, and estimate demand equations for local, long distance, national and international toll traffic.

The equations have been specified and estimated using cointegration techniques. We present estimations of both long run and short run equations for each type of traffic (two steps technique), as well as equations estimated jointly, non linearly in one step. The equations are of the double log type, except for the price, for which we use a log linear form to allow for the price elasticity to increase with the price itself. The adequacy of the assumptions underlying the method of estimation is assessed using a battery of diagnostics for each equation, which are presented in the appendixes.

The conclusions that can be drawn from this analysis with respect to output and price elasticities are the following. Long run output elasticities vary between 0.46 for long distance calls and 1.38 for international calls. They are smaller than the corresponding elasticities for the residential sector of long run price elasticities, (Pérez, 1993). Price elasticities are also generally smaller than those for the residential demands of Pérez (1993) and vary from -0.24 to -0.14 for local traffic, to -0.40 to -0.20 for long distance traffic. We haven't been able to obtain a meaningful long run price elasticity for international demand.

These results suggest that it would be very useful to undertake further research on the demand for international traffic using panel data for different countries. The estimation of demands using panel data on individual firms from different sectors should also prove very fruitful. The analysis of the demand of a variety of new services is another promising field for further research.

Notes

1. The homogeneization procedure consists in recalculating the number of pulses generated by the observed traffic in each of the previous years, according to the tariff structure of 1991. This procedure seeks to make comparable the amounts of traffic for different years. This process is needed because the number of conversation minutes and messages were not recorded for this period.

2. The figure for national toll traffic is recorded in the measuring stations; later on, it is split between local toll and long distance toll following a heuristic procedure. The figures for national toll traffic are considered more reliable than each of its two components.

3. Examples can be easily constructed wherein the sum of two demands gives rise to a total demand, which is more elastic than each of its two components. We do not have a good explanation, except that we have a problem with the aggregation.

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Appendix 1.

Table 2. Diagnostics of the one step estimation traffic models.

DIAGNOSTIC	ONE STEP ESTIMATION			
	LOCAL	LONG DISTANCE	NATIONAL	INTERNATIONAL
Omitted variables:				
Total lines$_t$	0.61	0.80	0.03	-0.70
Local price$_t$	1.79		1.83	
Long price$_t$		1.37	1.11	
Internat. price$_t$ (CEE)				0.04
Internat. price$_t$ (USA)				0.31
Imports plus Exports.				0.05
Dynamics:				
mce$_{t-2}$	-1.15	-0.85	-1.47	0.69
mce$_{t-3}$	-1.86	-0.71	-1.64	-0.27
mce$_{t-4}$	0.36	1.27	1.35	0.25
mce$_{t-5}$	0.58	1.22	1.02	-0.89
dlpib$_{t-1}$	-0.16	-0.71	-0.92	0.19
dlpib$_{t-2}$	0.74	1.08	1.06	-0.15
dlpib$_{t-3}$	-0.71	0.59	-0.08	0.60
dlpib$_{t-4}$	-1.22	-1.66	-1.57	-0.63
dindcmu$_{t-2}$	0.33		0.03	
dindcmu$_{t-3}$	1.71		1.54	
dindcmu$_{t-4}$	-1.03		-0.84	
dindcmiu$_{t-2}$		1.13		
dindcmiu$_{t-3}$		1.33		
dindcmiu$_{t-4}$		-0.64		
dindcmia$_{t-1}$				1.00
dindcmia$_{t-2}$				-0.22
dindcmia$_{t-4}$				1.33
dlurblin$_{t-5}$	0.85			
dlurblin$_{t-6}$	-0.03			
dlurblin$_{t-7}$	-1.39			
dlurblin$_{t-8}$	0.65			
dlirblin$_{t-5}$		1.88		
dlirblin$_{t-6}$		-0.25		
dlirblin$_{t-7}$		-1.54		
dlirblin$_{t-8}$		0.97		
dlnaclin$_{t-5}$			1.63	
dlnaclin$_{t-6}$			-0.07	
dlnaclin$_{t-7}$			-2.12	
dlnaclin$_{t-8}$			0.95	
dliallin$_{t-5}$				-0.97
dliallin$_{t-6}$				0.30
dliallin$_{t-7}$				0.57
dliallin$_{t-8}$				-0.13

Table 2. (Cont.) Diagnostics of the one step estimation traffic models.

DIAGNOSTIC	ONE STEP ESTIMATION			
	LOCAL	LONG DISTANCE	NATIONAL	INTERNATIONAL
Functional form:				
inverse of $dlpib_t$	0.14	0.57	0.65	-1.06
inverse of $dindcmu_t$	0.52		-0.37	
inverse of $dindcmiu_t$		-0.79		
inverse of $dindcmia_{t-3}$				-0.23
square of $dlpib_t$	-1.06	-0.46	-0.67	0.54
square of total $lines_t$	0.54	0.76	-0.09	
square of $dindcmu_t$	-1.93		0.97	
square of $dindcmiu_t$		0.48		
square of $dindcmia_{t-3}$				0.32
square of mce_{t-1}	-0.07	0.95	0.28	0.74
square of $dlurblin_{t-4}$	-0.38			
square of $dlirblin_{t-4}$		-0.61		
square of $dlnaclin_{t-4}$			-1.17	
square of $dliallin_{t-4}$				-1.44
square of $dlentraa_t$				-0.51
Static Heteroscedasticity:				
mce_{t-1}	0.89	1.37	1.21	0.10
square of mce_{t-1}	-2.36	-1.37	-2.18	-0.17
total $lines_t$	-1.55	-0.11	-0.23	
square of total $lines_t$	-1.53	-0.14	-0.22	
$dlpib_t$	-1.61	-0.52	-1.29	0.03
square of $dlpib_t$	-0.43	-0.94	-1.50	-0.72
$dindcmu_t$	2.72		0.95	
$dindcmiu_t$		1.00		
$dindcmia_{t-3}$				-0.01
square of $dindcmu_t$	2.06		-0.07	
square of $dindcmiu_t$		-0.46		
square of $dindcmia_{t-3}$				-0.51
$dlminusa_t$				0.25
square of $dlminusa_t$				0.25
Breusch-Pagan	0.03	1.03	0.07	2.46
Dynamic Heteroscedasticity:				
ARCH(1)	-1.38	-0.87	-0.97	-0.08
ARCH(2)	0.19	-0.38	0.28	-1.94
ARCH(3)	-0.58	0.76	-0.70	-1.36
ARCH(4)	-0.98	-0.80	0.32	0.03
ARCH(5)	1.53	-0.16	0.47	2.48
ARCH(1-5)	0.93	0.43	0.43	1.84
Normality:	0.77	0.01	0.96	1.16
Chow(85:IV):	-0.67	0.01	0.06	0.01
Augmented Dickey-Fuller:	-6.79	-7.36	-6.57	-7.76

Except the Chow test, all diagnostics are lagrange multipliers tests (see Godfrey (1988)). We use, when feasible, the version of the t, which allows unidirectional diagnostics and has better finite sample properties. Critical value of t_{40}= 2.021.

Appendix 2. Graphics of the business traffic models.

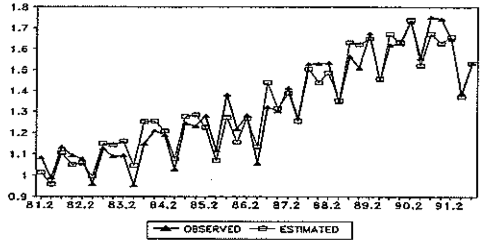

Figure 1 Estimated versus observed values of the local traffic model.

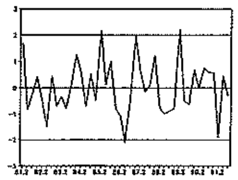

Figure 2 Residuals of the local traffic model.

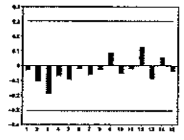

Figure 3 ACF

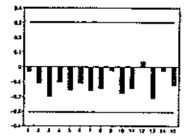

Figure 4 PACF

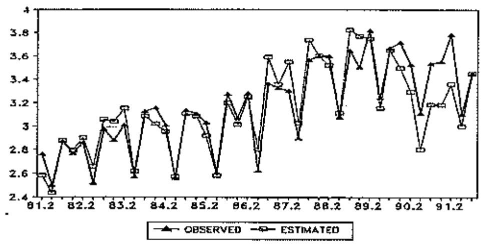

Figure 5 Estimated versus observed values of the long distance traffic model.

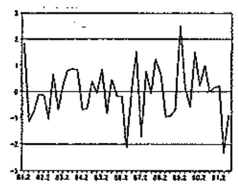

Figure 6 Residuals of the long distance traffic model.

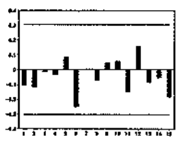

Figure 7 ACF

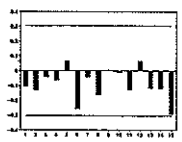

Figure 8 PACF

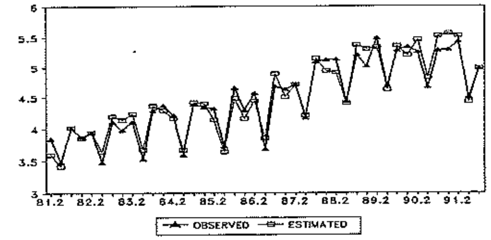

Figure 9 Estimated versus observed values of the national traffic model.

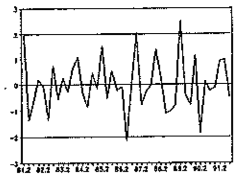

Figure 10 Residuals of the national traffic model.

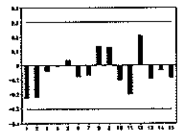

Figure 11 ACF

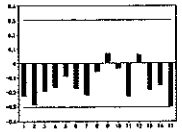

Figure 12 PACF

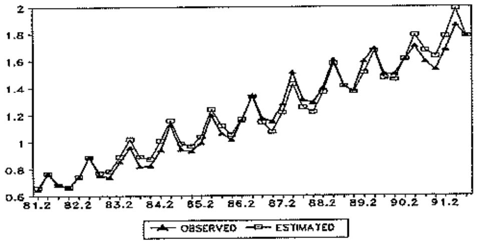

Figure 13 Estimated versus observed values of the international traffic model.

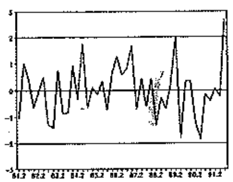

Figure 14 Residuals of the international traffic model.

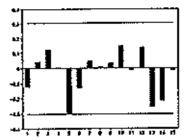

Figure 15 ACF

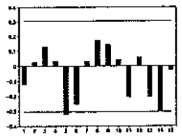

Figure 16 PACF

SERIE DE DOCUMENTOS DE TRABAJO DEL *ICAE*

9301: *"Análisis del Comportamiento de las Cotizaciones Reales en la Bolsa de Madrid bajo la Hipótesis de Eficiencia"*. Rafael Flores de Frutos. Diciembre 1992.

9302: *"Sobre la Estimación de Primas por Plazo dentro de la Estructura Temporal de Tipos de Interés"*. Rafael Flores de Frutos. Diciembre 1992.

9303: *"Cambios de Estructuras de Gasto y de Consumo en el Cálculo del IPC"*. Antonio Abadía. Febrero 1993. (Versión final publicada en Revista de Economía Aplicada, Vol.1, Nº1)

9304: *"Tax Analysis in a Limit Pricing Model"*. Félix Marcos. Febrero 1993.

9305: *"El Tipo de Cambio Propio: Reformulación del Concepto y Estimación para el Caso Español"*. José de Hevia Payá. Junio 1993.

9306 *"Price Volatility Under Alternative Monetary Instruments"*. Alfonso Novales. Abril 1992.

9307 *"Teorías del Tipo de Cambio: Una Panorámica"*. Oscar Bajo Rubio. Simón Sosvilla Rivero. Junio 1993. (Versión final publicada en Revista de Economía Aplicada, Vol.1, Nº2).

9308 *"Testing Theories of Economic Fluctuations and Growth in Early Development (the case of the Chesapeake tobacco economy)"*. Rafael Flores de Frutos. Alfredo M. Pereira. Diciembre 1992.

9309 *"Maastricht Convergence Conditions: A Lower Bound for Inflation?"*. Jorge Blázquez. Miguel Sebastián. Marzo 1992.

9310 *"Recursive Identification, Estimation and Forecasting of Nonstationary Economic Time Series with Applications to GNP International Data"*. A. García-Ferrer. J. del Hoyo. A. Novales. P.C. Young. Marzo 1993.