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DEMAND FOR TELEPHONE LINES AND UNIVERSAL SERVICE IN SPAIN

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ABSTRACT

In this paper we use a model of demand for telephone lines to derive an econometric model of the net demand for new access lines in Spain, for the period 1980-1993, using quarterly observations.

We use cointegration techniques to obtain long and short run equations, both estimated separately in two steps and jointly. The results show a strong sensitivy of the net demand for new lines to domestic usage price with an elasticity greater than one, an income elasticity also greater than one, and an elasticity with respect to price of access, in absolute value, less than one. We find that a tariff restructuring that lowers international and long distance rates while raises access rates might have a very small effect on the net demand for new lines.

This suggests that the objective of universal service might be compatible with the kinds of tariff restructuring that have been recently considered in Spain.

RESUMEN

Este trabajo hace una evaluación del coste del Servicio Telefónico Universal en España en la nueva situación de competencia. Para ello especificamos un modelo econométrico de la demanda neta de nuevas líneas telefónicas en España para el período 1980-93.

Especificamos ecuaciones a corto y largo plazos, estimadas tanto de manera separada como conjuntamente. Los resultados sugieren una fuerte sensibilidad de la demanda neta de nuevas líneas al precio del uso nacional, con una elasticidad mayor que la unidad; una elasticidad renta también mayor que la unidad y una elasticidad con respecto al precio del acceso menor que uno en valor absoluto. Partiendo de las estimaciones anteriores, ilustramos que una reestructuración de precios que rebaja las tarifas internacionales y de larga distancia al tiempo que eleva la cuota de abono puede tener un efecto muy pequeño sobre la demanda neta de nuevas líneas.

Esto sugiere que el objetivo de servicio universal puede ser compatible con el tipo de reestructuraciones de tarifas que se han propuesto recientemente en España.

1. INTRODUCTION

The Spanish telecommunications sector has developed in a monopolistic environment. Cross subsidies have contributed to the objective of universal service, though a more competitive environment will press the operating company to design an alternative tariff structure. These changes in tariffs could affect the objective of universal service, which has been the main justification for maintaining the monopoly.

We want to analyze the effect of tariff restructuring on the objective of universal service. That is, measure how a tariff restructuring could affect the net demand for new lines. The net demand for new access lines, provided that a waiting list does not exist, should be equal to the number of new lines minus the cancellations; on the other hand if a positive waiting list exists, the supply would need to meet the net demand of the period plus the waiting list.

In this study we use a model of demand for access (telephone lines), highlighting two basic features: 1. Usage of the telephone is conditional upon access to the network. 2. Access, in turn, is dependent upon the net benefits from usage in relation to the price of access.

In Spain, the installation charge is relatively high (197 Ecus in 1991) while the monthly recurring charges are relatively low when compared with the rest of EEC countries, see Caballero and Alvarez (1995). Both the long distance domestic and international usage prices are also high. A tariff restructuring is under way to reduce cross subsidization between services and facilitate the introduction of competition. The universal service is based on three principles: universality, equality and continuity; facilitating access to the basic telephone service at an affordable price. In Spain, the household penetration rate[1] is 91.7 % in 1996.

The pioneer studies associated with modelling telephone demand were developed in the early 1970's in a series of papers in the Bell Journal of Economics by Artle and Averous (1973), Perl (1983), Squire (1974), Rohlfs (1974), Von Rabenau and Stahl (1974) and Littlechild (1975) and followed by Bodnar et al.(1988), Kridel (1988), and Taylor and Kridel (1990). Despite its importance, the demand for access has not received much empirical

[1] Measured as the number of residential fixed lines per one hundred households.

attention e.g: Rash (1971), Davis (1973), Waverman (1974), Feldman (1976), Pousette (1976), Alleman (1977), Southern New England Telephone (1977) and Perl (1978). However, access demand has received considerable attention in Spain: see Treadway (1974), Martín (1985), Barroso (1985), Hernández (1988), López (1988), Torres (1989) and Mauleón (1991). Meanwhile, usage demand has received relatively less attention in Spain. For estimates of price and income elasticities of the net demand for new access lines and also demand for usage, see Mauleón (1991), Pérez-Amaral (1993), Ocaña and Sánchez (1994), Pérez-Amaral et al. (1995) and Garín and Pérez-Amaral (1995).

The rest of the paper is organized as follows: in Section 2 we present a theoretical model of aggregate net demand for lines. Section 3 describes the data used in the study. In Section 4 we present the estimations. Section 5 contains further results. In section 6 we compare the results with those from previous studies. Section 7 analyzes the effects that a tariff restructuring can have on the universal service. Section 8 presents the conclusions.

2. A THEORETICAL MODEL OF AGGREGATE DEMAND FOR TELEPHONE SERVICES

The theoretical model is based on Artle and Averous (1973), Rohlfs (1974), Squire (1973), and Taylor (1994). We develop a model of aggregate net demand for lines in which the demand for new lines is related to the price of access, income and domestic usage price. Neither Artle and Averous nor Rohlfs distinguish between access and use. The demand for access is a function of income, price of access and prices of use. The demand for access (telephone lines) is also an option demand, see Taylor (1994). In this situation, the consumer is willing to pay something for the option to make calls even though the option may not be exercised.

2.1 THE RESIDENTIAL DEMAND FOR TELEPHONE TRAFFIC

The model of the demand for residential telephone traffic is presented in Taylor (1994) from where we borrow the discussion. For deriving the demand for use and access we combine the procedures of Rohlfs (1974) and Squire (1973).

In the first stage, the net benefits from use of the telephone system by an individual are calculated conditional on access. In stage 2, the net benefits are compared with the cost of access to determine whether access will in fact be purchased.

Following Artle and Averous and Rohlfs we define a dichotomous variable δ such that it takes the value 1 if the consumer is connected to the telephone system and zero otherwise. The consumer's utility function has as arguments the number of telephone calls (q), the quantity of a composite good (x), and the number of subscribers to the telephone system (N), reflecting the positive network externality due to the system size, i.e, the utility that a subscriber derives from a communications service increases as others join the system.

$$U = U(\delta q, x, N) \qquad U'_q>0,\ U'_x>0,\ U'_N>0. \tag{1}$$

The partial derivates are positive; in particular, the latter partial derivative reflects the positive network externality due to the system size. Connection of a new subscriber confers a benefit to existing subscribers because the number of telephones that can be reached is increased. This network externality (access or subscriber) was introduced by Artle and Averous (1973). The use externality was introduced by Rohlfs (1974). A telephone call requires the participation of a second party, but this party obtains the benefit of communicating without paying for the call.

The individual consumer maximizes his/her utility in equation (1) subject to the budget constraint

$$\delta\,(r + \pi\, q) + p\, x = y \tag{2}$$

where r is the price of access to the telephone system, π price of a call, p is the price of the composite good and y the income of the consumer.

From the first-order conditions and budget constraint, the demand functions for calls and all other goods can be derived.

$$q = q(\pi, p, N, y\text{-}r) \tag{3}$$

$$x = x(\pi, p, N, y\text{-}r) \tag{4}$$

These functions differ from conventional demands in two respects:

a) The demand functions depend upon the number of subscribers (N).

b) The budget constraint is y-r, which reflects the conditionality of use on having purchased access to the telephone system.

The consumer's net benefit from using the telephone system is measured by the consumer's surplus associated with a customer's use of the network. Let the inverse demand function for calls be π = g(q, N, p, r, y-r), the consumer's surplus from making q calls will be given by:

$$S = \int_0^q g(z, N, p, y-r)\, dz - \pi q \qquad (5)$$

In stage 2, the consumer's net benefit (S) from using the telephone system is compared with the cost of access to the system (r). Thus,

if $S \geq r$ (the consumer will subscribe to the system) (6)

if $S < r$ (the consumer will not subscribe to the system)

If $\delta=1$ the demand functions will be given in expressions (3) and (4). If $\delta=0$ then q=0 and the demand function of the composite good (x) would be x=y/p. The previous analysis suggests that aggregate demands for use could be written as:

$$Q_i = Q_i\ (p,\ Y,\ \pi,\ T,\ r) \qquad (7)$$

where Q_i denotes the total number of each type of calls made by all subscribers, and Y is the aggregate income of the economy, and T is the total number of lines. The partial derivate with respect to Y, T and the number of subscribers to the telephone system (N) should be positive, whereas the partial derivates of Q_i with respect to the price π_i should be negative and the partial derivates of Q_i with respect to the price of other goods might be positive or negative reflecting substitutability or complementarity of the goods or services.

2.2 DEMAND FOR BUSINESS TELEPHONE TRAFFIC

Business demand for telephone services is related to the maximization of profits. For business customers communication is an input for the production of other goods. The firm's production function will determine its demand function for telephone calls. The production function for the firm could be represented by:

$$f\ (l,\ q,\ y) = 0 \qquad (8)$$

where l is the number of trunk lines installed in a given firm, q is the vector of quantities of telephone services in a period of time and y is the vector of products and other inputs of the firm. Under general conditions, the optimization problem of the firm can be solved and an aggregate demand for telephone services by the business sector could be represented by:

$$B_i = B_i\ (L,\ p,\ \pi,\ Y) \qquad i=1,\ \ldots,\ I. \qquad (9)$$

where L is the total number of trunk lines in service in the business sector, and Y is a measure of aggregate output. The heterogeneity of businesses makes further disaggregation of business demand necessary. The partial derivates with respect to T and Y must be positive, while the partial derivates with respect to price must be negative and the cross elasticities might be positive or negative, which reflects the substitutability or complementarity of the inputs.

2.3 THE DEMAND FOR TELEPHONE LINES

Let M denote the size of the population and N the number of suscribers to the telephone system. Let δ_n be a dichotomous variable that takes the value of 1 if the nth individual suscribes to the telephone system and 0 otherwise. The quantity to explain is the proportion of the population having access to the telephone system (demand for access), N/M. Following expression (5), S_n represents the consumer's surplus of individual n associated with his or her use of the telephone system.

$$S_n = \int_0^{q_n} g(q,\ N,\ p,\ \mu_n - r)\ dq - \pi\ q \qquad (10)$$

From (6)

$\delta_n = 1$ if $S_n \geq r$

$\delta_n = 0$ if $S_n \leq r$

δ_n is a function of π, p, N, r and μ_n. δ_n will vary across individual consumers in the population either because of differences in preferences or because of differences in income. We will assume that everyone has the same preferences. $N = \sum_{n=1}^{N} \delta_n$ and since δ_n depends on the value of $S_n - r$, N will depend on the distribution of $S_n - r$. Since preferences are assumed not to vary, the distribution of $S_n - r$ will depend on the distribution of income. Hence N will depend on the distribution of income. In particular, for given M, and with S_n treated as a random variable, N will be determined by the probability that S_n is greater than r, namely:

$$P(S_n > r) = 1 - F(r) = 1 - \int_0^r f\ (S_n)\ dS_n \qquad (11)$$

Under our assumption, the distribution of S_n will be related to the distribution of income via the "change of variable" from μ_n to S_n as defined in expression (11).

$f(S_n)$ will be related to $h(\mu_n)$ according to $f(S_n) = h[\mu_n(S_n)]$ (12)

The other arguments are implicit in (10), namely, q_n, p, N, and Y are subsumed into the shape of $\mu_n(S_n)$. Let H denote the distribution function of μ_n. We can reformulate expression (11) as:

$$P(S_n > r) = P(\mu_n > \mu^*(r)) = 1 - H[\mu^*(r)] = 1 - \int_0^{\mu^*(r)} h(\mu_n)\, d\mu_n \qquad (13)$$

which yields

$$\frac{N}{M} = \int_{\mu*(r)}^{\infty} h(\mu_n) d\mu_n \qquad (14)$$

The expression represents a discrete choice model, in which, $\mu^*(r)$ can be interpreted as the "threshold" value of income. If the threshold is exceeded, the consumer subscribes to the telephone system; if the threshold is not reached, the consumer does not subscribe. The proportion of the population demanding access to the telephone system will be determined by the distribution of income. On the other hand, for the business what is relevant is the type of access (single line, multi single lines, PBX trunks, WATS, ...) that a business demands and the number of lines. According to equations (10), (12), and (13), we can rewrite expression (14) as

$$\frac{N}{M} = \Phi(p, Y, \pi, r, T) \qquad (15)$$

where T represents the total number of lines in service (business plus residential customers).

Thus, the demand for access to the telephone system depends on the demand for use of the system. In making this connection precise Squire (1973) relates the demand for access to the demand for use in a consumer's surplus framework.

An alternative approach is to relate the net demand for new access lines directly to the volume of usage. In this case the net demand for new access lines is a function of the prices of access and the volume of usage. Income and price of usage do not appear directly as predictors, but rather indirectly as determinant factors of the volume of usage. The net demand for new access lines may be a function of the volume of usage in the recent past. In this case, there will be no simultaneity and estimation can proceed by OLS.

Equation (7) represents the aggregate demand for use of the telephone system and equation (15) represents the aggregate demand for access to the system.

3. THE DATA

We distinguish between the total number of subscribers to the telephone system at a point in time (total demand) and the variation in the number of subscribers (net demand) in a period of time. The total demand (D) is composed of the number of lines in service (L) together with the waiting list (WL).

The net demand for new access lines is defined as the sum of gross total requests minus cancelled requests minus the cancellations of service.

L:	Lines in service.	R: Total Requests.
WL:	Waiting list.	CR: Cancelled Requests.
D:	Total Demand.	C: Cancellations of service.
ND:	Net Demand.	

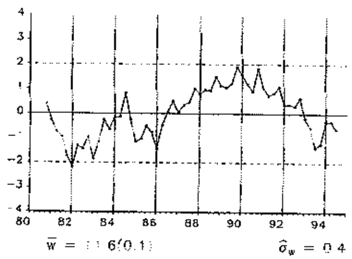
$D = L + WL$

$$\Delta L + \Delta WL = \Delta ND = R - CR - C \qquad (16)$$

The net demand for new access lines presents the following evolution during the sample period from 1980.I to 1993.IV:

Graph 1.

Net Demand for New Lines in Spain (standardized)



Spanish quarterly telephone data were obtained from Telefonica de España (1990, 1992). Aggregate income is measured by quarterly gross domestic product, which was obtained from database M° Economía y Hacienda. The prices used are the installation charge and monthly recurring charges deflated by the consumer price index (CPI). The CPI was obtained from Banco de España (1993). With respect to the tariffs for traffic, which decreased in real terms during the sample period, Telefonica's Paasche price indexes have been used.

4. THE MODEL AND ESTIMATIONS

We present equations that have been derived from the theoretical model, adapting them to the available Spanish data. The equations were estimated with quarterly data for the period 1980.I to 1993.IV. All variables except the domestic usage price are in natural logs. The t ratio is below each coefficient, in brackets. We use cointegration techniques to model long run and short run relationships, following the methodology of Engle and Granger (1987), in two steps. First we estimate the long run relationship by OLS and test for the stationarity of the residuals (that is, if residuals are I(0), the test employed for the stationarity of the long run residuals is the ADF test). Second, if this is not rejected, we specify an Error Correction Model to model the short run behaviour.

There are, however, a number of potential problems associated with this approach: a. small sample biases (Banerjee et al.1986) since it relies on a superconvergence result, and b. the possibility, not considered in their approach, of multiple cointegrating vectors. In order to avoid these problems in small samples we estimate the short run and long run relationships both in two steps and jointly in one step.

The net demand for new lines is modelled as a function of the price of access, income, a variable for the size of the telephone system (population), the price of usage and the total number of lines in service (business and residential customers). Neither the total number of lines variable in service nor the population variable were significant in this sample in the specified model. The long run equation passes the ADF test for cointegration. All the variables have a unit root at the zero frecuency (see Appendix). This long run relationship can be interpreted as a long run equilibrium condition if the resulting residuals are stationary. The variables of the long run relationship are:

lnd:	log of net demand.
lrip:	log of installation charge.
lrmpr:	log of residential monthly recurring charge.
lpib:	log of quarterly gross domestic product.
rpdom:	the real domestic price of a homogenous pulse.
d:	dummy variable equal to 1 in 1992.IV and 0 otherwise.
η:	residuals from the long run equation; it will be the error correction mechanism in the short run equation.

$$lnd_t = \underset{(4.92)}{12.78} - \underset{(-3.32)}{0.56}\, lrip_t - \underset{(-5.04)}{0.93}\, lrmpr_t + \underset{(3.19)}{1.25}\, lpib_t \qquad (17)$$

$$- \underset{(-3.55)}{0.038}\, rpdom_t - \underset{(-2.72)}{0.50}\, d_t + \hat{\eta}_t$$

$R^2 = 0.83$, $F = 48.23$,

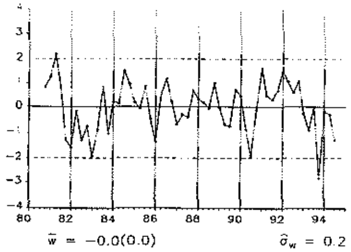
$\hat{\sigma} = 0.178$, D-W = 1.28,

ADF = - 4.45(D-W = 1.98) T = 56.

Sample period, 1980.I to 1993.IV, t statistics in parenthesis. The first D-W statistic refers to equation (17) and the second is from the equation used to compute the ADF statistic. The residuals from the long run equation present the following evolution:

GRAPH 2.

Residuals of Long Run Equation of Net Demand for New Lines.



The estimated values for the long run elasticities are shown in Table 1. In brackets are t ratios estimated by OLS.

Table 1.

Price and Output Elasticities for the Net Demand for Telephone Lines.

VARIABLE	LONG RUN ELASTICITY
INSTALLATION CHARGE	-0.56 (-3.32)
OUTPUT	1.25 (3.19)
USAGE DOMESTIC PRICE	-1.78 (-3.55)
RESIDENTIAL MONTHLY RECURRING CHARGE	-0.93 (-5.04)

The estimated value for the long run elasticity to output is 1.25(0.39) and long run elasticities with respect to the price of access (installation charge and residential monthly recurring charge) of - 0.56(0.17) and - 0.93(0.18) respectively. The long run price elasticity of the net demand for new lines with respect to the real domestic price of a pulse is - 1.78 in the average of the price index and - 1.84 at the end of the sample period. These results suggest that the net demand for new lines is very sensitive to changes in income, price of access and domestic usage price.

The empirical evidence suggests long run elasticities for the demand for calls of at least 1 for income and in the neighborhood of -1 for price. The price elasticity for use seems larger than the price elasticity for access. The estimated price elasticity for access seems higher than in previous empirical studies (see Taylor, 1994). As it should be expected the elasticity with respect to the installation charge (-0.56) is smaller in absolute value than the elasticity with respect to recurring charges (-0.93). A small price elasticity and a moderate income elasticity is what one might expect. We must take into account that we use as dependent variable the net demand for new lines.

As a result, an increase in the domestic usage price of 1 % results in a decrease of - 1.78 % in the net demand for new lines. The net demand for new lines in the long run need not be equal to zero. Artle and Averous (1973) show that interdependent demand can sustain continuous growth in a stationary population with stationary income. In this model, we do not take into account demographic factors since they come out insignificant in our sample.

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

- dlnd: rate of growth of the net demand for new access lines.
- dlrip: rate of growth of the installation charge.
- dlrmpr: rate of growth of the residential monthly recurring charge.
- dlpib: rate of growth of the gross domestic product.
- drpdom: change in the real domestic price of a pulse.
- di: dummy variable equal to 1 in 1989.IV and 1992.IV and 0 otherwise.

$$dlnd_t = -\,0.30\,dlrip_t - 0.77\,dlrmpr_t + 3.00\,dlpib_t \qquad (18)$$
$$\quad (-1.64) \qquad (-2.62) \qquad (1.65)$$
$$-\,0.02\,drpdom_t + 0.22\,dlnd_{t-4} - 0.37\,d1_t - 0.72\,mce_{t-1} + \hat{\varepsilon}_t$$
$$\quad (-2.43) \qquad (2.61) \qquad (-4.10) \quad (-6.21)$$

$R^2 = 0.72$, $F = 19.03$,

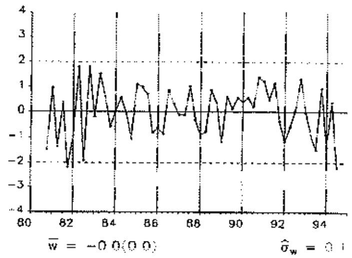
$\hat{\sigma} = 0.13$, D-W = 2.17,

ADF = - 4.50(D-W = 1.97) T = 51.

Sample period; 81.II to 93.IV. t statistics in parenthesis. The residuals from the short run equation are shown in Graph 3.

GRAPH 3.

Residuals of Short Run Equation of Net Demand for New Lines.



The joint nonlinear estimation of Eqs.(17) and (18) is:

$$dlnd_t = -0.30\ dlrip_t - 0.77\ dlrmpr_t + 14.38\ dlpib_t - 0.02\ drpdom_t + 0.21\ dlnd_{t-4}$$
(-1.30) (-1.76) (1.34) (-1.26) (1.92)

$$-0.62(lnd_{t-1} - 5.18 + 0.68\ lrip_{t-1} + 0.95\ lrmpr_{t-1} - 2.05\ lpib_{t-1}$$
(-4.50) (0.82) (-2.43) (-3.23) (2.84) (19)

$$+ 0.01\ rpdom_{t-1}) + 0.35d2_t + \hat{\eta}_t$$
(-0.44) (-2.15)

$R^2 = 0.67$, $DW = 2.37$,

$\hat{\sigma} = 0.146$, $T = 51$.

ADF = 12.48(DW = 1.00),

Sample period, 1981.II to 1993.IV. This estimation is robust to the choice of initial conditions, and the values of the estimated parameters are of the same order as the ones in the procedure in two steps.

We obtain a short run output elasticity of 3.00(2.22) and a short run installation charge and residential monthly recurring charge elasticities of - 0.30(0.18) and - 0.77(0.29). The estimated elasticity for the domestic usage price in the average of the price index is -1 and at the end point of the sample period is - 0.97. Standard deviations in parenthesis. The short run equation passes a battery of diagnostics which are shown in the Appendix.

In all EU countries the long distance charges exceed costs. The additional revenues are used to subsidise the local service and access. With the rebalancing of tariffs the cross subsidisation will be lowered. The increase in local charges may be greatly offset by lower long distance rates. However, that change of tariffs will imply a redistribution among customers. It is important to highlight that net demand for new lines is quite sensitive to changes in domestic usage price and an increase in local charges will have a negative effect on the net demand for new lines, and at the same time, lower usage prices will have a positive effect. The net effect will depend on the relative magnitudes of the changes as well as the price elasticities; several scenarios are analyzed in section 7.

5. FURTHER RESULTS. DISAGGREGATION BY TYPES OF CUSTOMERS

In this section we specify separate equations for the net requests distinguishing between residential and business customers. In this way our results will improve by the use of disaggregated data and by analyzing each component of the aggregate net demand. We obtain specific price and income elasticities for business and residential net requests. The domestic usage price was not significant in the following equations. We use cointegration techniques to model long run and short run relationships and estimate both in two steps jointly in one step. Our elasticities are shown in Table 2. A battery of diagnostics, shown in the Appendix, is applied to the dynamic equations.

A. Residential net requests

The variables of the long run equation are:

lrnr:	natural logarithm of residential net requests,
d2:	dummy variable for the second quarter,
lrip:	natural logarithm of real installation charge,
lpib:	natural logarithm of gross domestic product,
lrmpr:	natural logarithm of residential monthly recurring charge,

$$lrnr_t = 3.05 - 0.66\ lrip_t - 0.50\ lrmpr_t + 1.95\ lpib_t - 0.10\ d2_t + \hat{\mu}_t \quad (20)$$
(2.01) (-9.32) (-4.10) (11.31) (-2.40)

$R^2 = 0.84$, $F = 66.20$,

$\hat{\sigma} = 0.13$, $DW = 1.02$,

ADF = - 3.85(DW = 2.00), $T = 56$.

Sample period, 1980.I to 1993.IV. Standard deviations in parenthesis. From this model, we obtain a long run elasticity of residential net requests to installation charge of -0.66(0.07), a value for the long run income elasticity of 1.95(0.17) and a long run elasticity with respect to residential monthly recurring charge of - 0.50(0.12).

Based on this long run equation, we model the short run. The variables employed are the following:

dlrnr:	rate of growth of residential net requests,
dlrip:	rate of growth of installation charge,
dlrmpr:	rate of growth of residential monthly recurring charge,

dlpib: rate of growth of gross domestic product,

$$dlrnr_t = -0.54\ dlrip_t - 0.91\ dlrmpr_t + 0.31\ dlrnr_{t-4} + 1.33\ dlpib_t - 0.48\ mce_{t-1} + \hat{a}_t \quad (21)$$
(-3.65) (-3.98) (3.4) (0.68) (-3.78)

$R^2 = 0.61$, $F = 18.12$,
$\hat{\sigma} = 0.11$, $DW = 2.44$,
$ADF = -4.82(DW = 1.98)$, $T = 51$.

The joint nonlinear estimation of Eqs. (20) and (21) is:

$$dlrnr_t = -0.44\ dlrip_t - 0.71\ dlrmpr_t + 0.36\ dlpib_t + 0.17\ dlrnr_{t-4} - 0.51(lrnr_{t-1}$$
(-2.72) (-2.52) (0.07) (1.58) (-3.91)

$$- 3.62 + 0.62\ lrip_{t-1} + 0.36\ lrmpr_{t-1} - 1.75\ lpib_{t-1} + 0.08\ d2_t) + \hat{\eta}_t \quad (22)$$
(-1.02) (3.11) (1.44) (-5.70) (1.68)

$R^2 = 0.67$, $DW = 2.29$,
$\hat{\sigma} = 0.11$, $T = 51$.
$ADF = -5.43(DW = 2.00)$,

Sample period, 1981.II to 1993.IV. This estimation is robust to the choice of initial conditions, and the values of the estimated parameters are of the same order as the ones in the two steps estimation. The parameters were estimated with greater standard errors. Notice that our estimation procedure does not impose restrictions in the estimation.

B. Business net requests

The variables of the long run equation are:

lbnr: natural logarithm of business net requests,
d2: dummy variable for the second quarter,
d3: dummy variable for the third quarter,
lrip: natural logarithm of installation charge,
lrmpb: natural logarithm of business monthly recurring charge,
lpib: natural logarithm of gross domestic product,

$$lbnr_t = 8.71 - 0.10\ lrip_t - 2.01\ lrmpb_t + 1.70\ lpib_t - 0.08\ d2_t - 0.18\ d3_t + \hat{b}_t \quad (23)$$
(1.98) (-2.10) (-5.48) (6.50) (2.38) (-5.23)

$R^2 = 0.95$, $F = 192.69$,
$\hat{\sigma} = 0.10$, $DW = 1.00$,
$ADF = -3.65(DW = 1.92)$, $T = 56$.

Sample period, 1980.I 1993.IV. In this model, the long-run elasticity to output is 1.70(0.26), the price elasticity to installation charge is of -0.10(0.04) and the long-run elasticity to business monthly recurring charge is of -2.01(0.38). Based on this long-run relationship, we model the short run:

dlbnr: rate of growth of business net requests,
d: dummy variable equal to 1 in 1986.IV and 0 otherwise,
dlrip: rate of growth of installation charge,
dlrmpb: rate of growth of business monthly recurring charge,
dlpib: rate of growth of gross domestic product,

$$dlbnr_t = -0.14\ dlrip_t - 0.95\ dlrmpb_{t-1} + 0.72\ dlbnr_{t-4} + 0.18 d_t - 0.34\ mce_{t-1} + \hat{v}_t \quad (24)$$
(1.48) (-2.80) (10.75) (2.52) (-3.05)

$R^2 = 0.84$, $F = 62.88$,
$\hat{\sigma} = 0.07$, $D\text{-}W = 1.77$,
$ADF = -4.93(DW = 2.06)$, $T = 51$.

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

$$dlbnr_t = -0.10\ dlrip_t - 0.76\ dlrmpb_{t-1} + 0.59\ dlbnr_{t-4} - 0.40(lbnr_{t-1} \quad (25)$$
(-0.92) (-1.72) (7.37) (-3.70)

$$- 12.25 + 0.02\ lrip_{t-1} + 2.24\ lrmpb_{t-1} - 1.40\ dlpib_{t-1}) + 0.08\ d_t + \hat{a}_t$$
(1.19) (0.22) (2.69) (-2.25) (0.94)

$R^2 = 0.84$, $DW = 1.92$,
$\hat{\sigma} = 0.08$, $T = 51$.
$ADF = 3.84(D\text{-}W = 2.97)$,

Sample period, 1981.II to 1993.IV. This estimation is robust to the choice of initial conditions, and the values of the estimated parameters do not vary significantly with respect to the ones in the two steps estimation. The standard errors are higher than in the two steps procedure.

6. COMPARATIVE ANALYSIS OF RESULTS

Other equations estimated by different authors are briefly presented and compared with those obtained in this paper:

A. Mauleón (1991).

The variables employed in this study were the following: total number of requested lines per capita, installation charge, gross domestic product per capita and total population.

(Total number of requested lines per capita)= - 0.038 (Installation charge) (26)

(4.3)

+ 0.94 (gross domestic product per capita)+ 3.1 (Population) + Seasonal dummies + $\hat{v}_t$

(6.2) (4.0)

Sample period from 1977.III to 1987.IV (42 observations). Type of data: quarterly. t ratios in brackets. The variables are in natural logs. In this case, there are omitted variables such as: the recurring charges (business and residential) and price of usage. The outcomes in terms of elasticities are different since the dependent variable is the total number of requested lines per capita and he employs a different technique of estimation (koyck distributed lag). In his study, the residential customers are more sensitive to installation charge than to the monthly recurring charge; on the other hand, the business customers are more sensitive to the monthly recurring charge than installation charge when he uses as dependent variable the net requests (see Table 2).

B. PNR & Associates (1994): The variables employed in this study were the following:

lnd:	log of the net demand for new lines.
Q_i:	seasonal dummies.
lrip:	log of installation charge.
lrmpr:	log of residential monthly recurring charge.
lrmpb:	log of business monthly recurring charge.

The short run equation:

$$lnd_t = 23.51 + 0.128E\text{-}02 Q_1 - 0.605E\text{-}01 Q_2 + 0.283E\text{-}01 Q_3 \quad (27)$$

(5.31) (0.20) (-0.89) (0.45)

$$+ 0.47\, lnd_{t-1} - 0.53\, lrip_t - 0.52\, lrmpr_t - 1.53\, lrmpb_t + \hat{\varepsilon}_t$$

(4.81) (-5.19) (-3.35) (-3.87)

Sample period from 1980.I to 1993.IV (56 observations). t statistics in parenthesis. Type of data: quarterly data. The model was estimated in Koyck distributed lag form. Neither of the usage prices turned out significant and gross domestic product was not significant. The installation charge and monthly recurring charges are highly significant. These results can be interpreted as short run elasticities. However, a long run equation was not included. The model passes the stability and cointegration tests. Possibly, in this model there are omitted variables such as income and price of usage. We could not use this estimated long run equation to evaluate different changes in tariffs, without taking into account the effect on the net demand for new lines of usage price.

In order to relate the estimated elasticities of our study to the results obtained in previous works we show Table 2. The comparison between different studies must be made carefully. For instance, Mauleón (1991) studies total demand for telephone lines, whereas in the study by PNR & Associates (1994) and in the present study we are considering the net demand for new lines (business and residential). In this paper we estimate the elasticities for the aggregate of the subscribers. The elasticities obtained in our study are smaller in the long run than the price elasticities of PNR & Associates'.

In the PNR & Associates' study the net demand for new lines is quite sensitive to changes in the business monthly recurring charge, whereas in our study the net demand is quite sensitive to changes of the recurring charges (residential plus business), income and domestic usage price. In Mauleón (1991), the elasticity of the demand for telephone lines with respect to installation charge is smaller than in the other studies mentioned, whereas the output elasticity is of 0.94. In his study, the residential customers are more sensitive to the installation charge than to the monthly recurring charge. In Table 2 we also include the results of the disaggregation by types of customers contained in Section 6.

Finally, both empirical studies have not devoted much attention to the possible effects of changes of tariffs on the net demand for new lines. It is also important to consider the effect of the usage price not only on the demand for use but also on the demand for access.

Table 2. Comparison of long run and short run elasticities

Study	Dependent Variable	Installation Charge LR	Installation Charge SR	Business Monthly Recurring Charge LR	Business Monthly Recurring Charge SR	Residential Monthly Recurring Charge LR	Residential Monthly Recurring Charge SR	Output LR	Output SR	Domestic Usage price LR	Domestic Usage price SR
Mauleón (1991)	Total Number of requested Lines	-0.038				-0.22				0.94	
Mauleón (1991)	Residential Net Requests		-1.2								
	Business Net requests	-0.27					-0.34				
PNR & Associates (1994)	Net Demand for New Lines	-1.00	-0.53	-2.88	-1.53	-0.98	-0.52				
(present study)	Net Demand for new lines	-0.56	-0.30			-0.93	-0.77	1.25	3.00	-1.78	-1.00
(present study)	Residential net demand for new lines		-0.66	-0.54			-0.50	-0.91	1.95	1.33	
	Business net demand for new lines	-0.10	-0.14	-2.01	-0.95			1.70			

7. UNIVERSAL SERVICE

The universal service obligation is associated with guaranteeing access to basic telecommunication services at affordable rates to a given population. The regulatory literature focuses mainly on the universal service obligations from the supply side, without taking into account either the effects of the liberalization or the tariff rebalancing on the demand side.

Two important questions arise when we deal with the universal service. First, the objective of the universal service should be precisely defined, i.e, which services, facilities, access and usage conditions should be affected and in which way. It is difficult to decide what services to include; this is mainly a political decision.

Second, it is necessary to evaluate the costs of providing universal service. In order to evaluate the cost of universal service obligations it is necessary to determine uneconomic areas and customers that the operator would not serve if it did not have the obligation to. Related questions are: how can this objective be financed and whether telecommunications operators must be forced to provide universal service.

In the Green Paper on Infrastructure, the EU considers financing universal service obligations via specific funds or interconnection payments.

Graham, Cornford and Marvin (1996) take a different approach with respect to the universal service obligations. They focus mainly on a demand side perspective and in particular whether the universal service policy should be extended to take into account the subscription, usage as well as access issues. They believe that the social benefits of completing a universal telephone network are high, and they are very difficult to estimate in order to evaluate this social objective.

In this paper we adopt a demand side approach to analyze the effect of some of the proposed tariff restructurings on the net demand for telephone lines in Spain. We proceed to evaluate the effects of changes in tariffs on the net demand for new telephone lines in Spain through alternative scenarios. We analyze different scenarios of price changes of local traffic, recurring charges and installation charge that have been recently considered in Spain.

The outcomes have been obtained under the assumptions specified in each column. In this simulation exercise we employ the long run and short run equations for the net demand for new lines eqs (17, 18). From Table 3 we obtain the following conclusions:

1. An increase in local tariffs and recurring charges by 20%, maintaining the installation charge, contributes to a decrease in long run net demand for new lines of -54.2% or of 46,394 lines per quarter.

2. An increase in local tariffs and recurring charges by 30% and a decrease in the installation charge of 10% contributes to a negative long run effect on the net demand for new lines of -27.6% or of 23,659 lines per quarter.

3. An increase in recurring charges by 30%, a decrease in the installation charge of 15% and a decrease in the domestic usage price by 10% contributes a small negative long run effect on the net demand for new lines of -1.7% or of 1,455 lines per quarter.

This suggests that a well targeted subsidy to those customers who decide not to demand telephones after the tariff rebalancing might maintain the same rate of growth of the demand for lines at a small cost. The subsidy would amount to 30% of the recurring, and 15% of the installation charge to those particular customers. The subsidy need not surpass the quantity of half a million dollars per year (which amount to less than 1% of the total revenue from local telephony in 1996), in order to maintain the demand for new telephone lines. This subsidy may be instrumented through a universal service fund, which in Spain will be administered by the Comisión del Mercado de las Telecommunicaciones (CMT).

Finally, the universal service policy should take into account the subscription and usage, as well as access issues. These results suggest that when the demand side is taken into account, the universal service obligation can be met in a liberalized environment with relatively low costs.

Table 3

Effects on the Net Demand for New Lines of different scenarios of tariff restructuring

	Scenario 1	Scenario 2	Scenario 3
Assumptions on changes of tariffs	Δ 20% local tariffs and recurring charges	Δ 30% local tariffs and recurring charges ∇ 10% installation charge	Δ 30% recurring charges ∇ 15% installation charge and ∇ 10% domestic usage price
Long run effect on the net demand for new lines	-54.2%(46,394)	-27.64%(23,659)	-1.7%(1,455)

8. CONCLUSIONS

In this study, we use a theoretical model of aggregate demand for access (telephone lines). We derive equations of aggregate net demand for new access lines and business and residential net requests. We use quarterly data for the period 1980.I-1993.IV. The equations have been specified and estimated using cointegration techniques. We present estimations of both long run and short equations (two-steps technique), as well as equations estimated jointly, non-linearly in one step for the net requests. A battery of diagnostics, shown in the Appendix, is applied to the dynamic equations.

The conclusions that can be drawn from this study with respect to price and income elasticities for access demand are the following. Income elasticities seem plausible, but slightly higher than those obtained in previous empirical studies; and vary from 1.25 in the long run to 3.00 in the short run. Price elasticities of demand for access are also generally greater than those obtained for the residential and business-residential sector in previous studies and vary between -0.56 in the long run and -0.30 in the short run for the installation charge; and from -0.93 in the long run to -0.77 in the short run for the residential monthly recurring charge.

In one step estimations the elasticities for the net demand for new lines are of the same order (except the elasticity to output) than in the procedure in two steps.

Additionally, we use specific equations for the net requests of business and residential customers. Long run output elasticities vary between 1.95 for the residential net requests and 1.70 for the business net requests. Short run output elasticity is 1.33 for the residential net requests. Long run price elasticities for the residential net requests are -0.66 with respect to installation charge and -0.50 with respect to residential recurring charge, whereas in the short run they vary between -0.54 and -0.91. Long run price elasticities for the business net requests are -0.10 with respect to installation charge and -2.01 with respect to monthly business recurring charge, whereas in the short run it is of -0.14 for the installation charge.

In one step estimations the long run output elasticity for the residential net requests is 0.36 and price elasticities for access are in the same order as the ones obtained in the two steps procedure.

We use these models to evaluate the effect that tariff restructurings of the magnitudes recently proposed may have on universal service in Spain. In particular we use equation 17 to evaluate the effect of different scenarios of tariff restructurings on the net demand for telephone lines. A tariff restructuring consisting of an increase in recurring charges by 30% and a decrease in installation charge and domestic usage price by 15% and 10% respectively could have a very small negative effect on the net demand for new lines. This small effect can be offset by a targeted subsidy program with a small cost to society or the operating company. In particular, we estimate that a subsidy of half million dollars per year (cumulative) could offset completely the negative effect of the tariff restructuring on the demand for telephone lines in Spain. This amounts to less than 1% of the income from voice telephony in 1996. This suggests that a tariff rebalancing and a liberalized environment can be compatible with the universal service objective in Spain.

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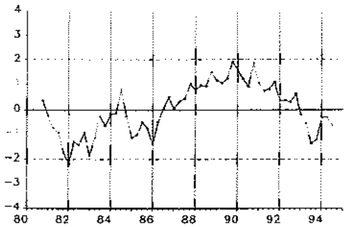
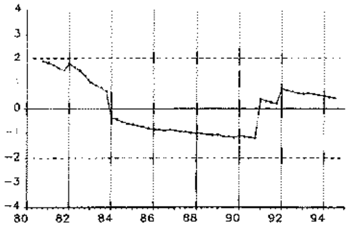
APPENDIX 1. PLOTS OF THE ORIGINAL SERIES (1980.I 1993.IV).

Lnd_t



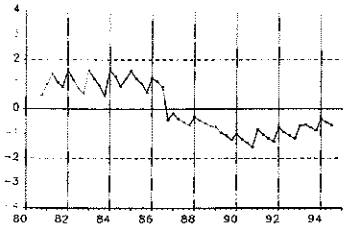
$\bar{w}$ = [illegible]6(0.[illegible])　　$\hat{\sigma}_w$ = 0.4

$Lnrip_t$



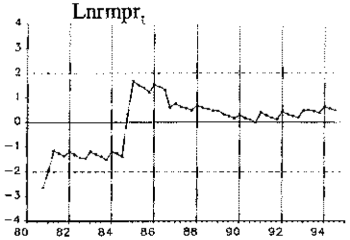
$\bar{w}$ = 8308.6(373.4)　　$\hat{\sigma}_w$ = 279

$Lrmpb_t$



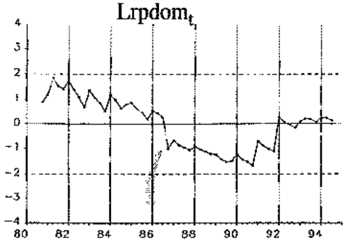
$\bar{w}$ = 482.5(6.1)　　$\hat{\sigma}_w$ = 45.7

$Lnrmpr_t$



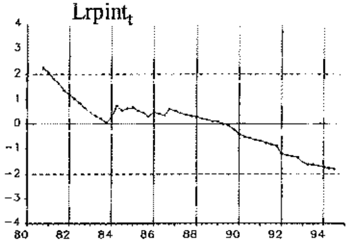
$\bar{w}$ = 4[illegible]2.7([illegible])　　$\hat{\sigma}_w$ = 82.9

$Lrpdom_t$



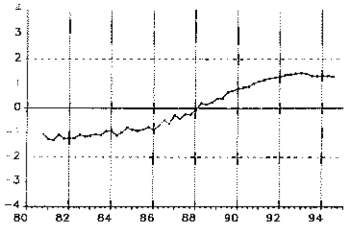
$\bar{w}$ = 47.6(0.7)　　$\hat{\sigma}_w$ = 5.5

$Lrpint_t$



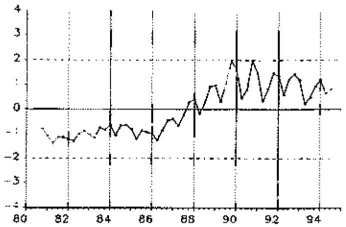
$\bar{w}$ = 35.0([illegible])　　$\hat{\sigma}_w$ = 7.9

$Lgdp_t$



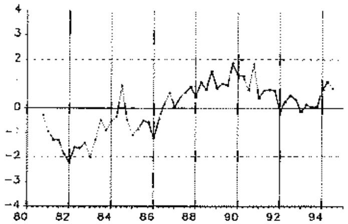
$\bar{w}$ = 4482.4(77.8)　　$\hat{\sigma}_w$ = 582.

$Lbnr_t$



$\bar{w}$ = 55408.7(3003.3)　　$\hat{\sigma}_w$ = 224

$Lrnr_t$



$\bar{w}$ = 131694.9(4867.5)　　$\hat{\sigma}_w$ = 364

Appendix. Diagnostics. Short Run Equations.

DIAGNOSTIC	NET DEMAND FOR NEW LINES	BUSINES NET REQUESTS	RESIDENTIAL NET REQUESTS
Omitted variables:			
Total lines$_t$	0.27	-0.08	0.11
Population$_t$	0.02	-0.35	0.01
International usage price$_t$	-0.42		-0.26
Residential monthly recurring charge$_t$	-0.11		0.59
Business monthly recurring charge$_t$		0.54	
Gross domestic product$_t$		-0.18	
Dynamics:			
mce$_{t-2}$	-0.42	-1.36	-1.43
mce$_{t-3}$	-0.05	-0.96	-0.29
mce$_{t-4}$	0.26	-0.55	0.12
mce$_{t-5}$	0.78	0.96	1.32
dlgdp$_{t-1}$	0.04		-0.97
dlgdp$_{t-2}$	0.45		-0.95
dlgdp$_{t-3}$	0.90		-0.87
dlgdp$_{t-4}$	0.57		-0.97
dlrip$_{t-1}$	0.91	0.48	1.36
dlrip$_{t-2}$	-0.30	0.20	-0.62
dlrip$_{t-3}$	0.11	-1.82	-1.30
dlrip$_{t-4}$	1.16	1.32	0.01
dlrmpr$_{t-1}$	-0.80		0.27
dlrmpr$_{t-2}$	1.04		0.43
dlrmpr$_{t-3}$	0.04		-0.90
dlrmpr$_{t-4}$	-1.00		-0.50
dlrmpb$_{t-1}$			
dlrmpb$_{t-2}$		1.64	
dlrmpb$_{t-3}$		-0.39	
dlrmpb$_{t-4}$		0.13	
drpdom$_{t-1}$	0.33		
drpdom$_{t-2}$	2.02		
drpdom$_{t-3}$	0.57		
drpdom$_{t-4}$	0.06		
Lagged dependent variable:			
l.d.v$_{t-5}$	3.10	-0.54	1.97
l.d.v$_{t-6}$	-1.46	-0.74	-1.32
l.d.v$_{t-7}$	-0.69	-0.16	-0.10
l.d.v$_{t-8}$	0.84	1.44	0.27
Autocorrelation:			
order 1	-1.16	0.89	-2.51
order 2	-0.47	-0.70	-1.06
order 3	-0.60	-1.24	-1.77
order 4	-0.10	-0.97	-0.16
order 5	-0.48	1.00	1.45
order 6	-1.66	-2.13	-1.44
Functional Form:			
inverse of dlpib$_t$	0.15	1.81	0.74
square of dlpib$_t$	-0.45	-0.97	-0.64
square of mce$_{t-1}$	1.76	0.45	1.20
square of dlrip$_t$	1.42	-0.33	-0.93
square of dlrmpb$_t$		0.39	0.86
square of dlbnr$_t$		0.62	0.10
square of dlrmpr$_t$	1.51		
square of dlrnr$_{t-4}$			
square of drpdom$_t$	1.20		
square of dlnd$_{t-4}$	1.94		
Dynamic Heteroskedasticity:			
ARCH(1)	0.17	-0.24	0.52
ARCH(2)	6.04	-0.41	2.20
ARCH(3)	6.65	-0.48	4.36
ARCH(4)	8.20	-0.56	4.92
White	11.14	10.75	12.00
Normality	1.4	2.20	0.55
Augmented Dickey Fuller	-4.30	-4.93	-4.82

Appendix. ADF Test for Cointegration.

We employed the ADF test (see, Dickey et al. 1984) test whose expression is:

$$\nabla y_t = c + \beta_t + (\phi - 1) y_{t-1} + \sum_{j=1}^{p} \nabla y_{t-j} + \nu_t$$

where $H_0: y_t \sim I(1)$ and $H_1: y_t \sim I(0)$

All variables show evidence of a unit root at the zero frequency. However, the presence of seasonality in our data complicates the estimation an testing procedures of models with cointegrated variables. In this study we use the HEGY test (see, Hylleberg et al. 1990). The HEGY test uses the following representation:

$$\nabla_4 y_t = \sum_{j=1}^{4} a_i Q_t^i + \sum_{i=1}^{4} b_i y_{i,t-1} + \sum_{i=1}^{k} c_i \nabla_4 y_{t-i} + \varepsilon_t$$

All the variables show evidence of a unit root at the zero frequency, while we found some contradictions between the rejection of seasonal roots.