Price Elasticities for Residential Demand for Telephone Calling Time.
An estimate on Swedish data*

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ABSTRACT

The paper shows how price elasticities for telephone calling time can be estimated when there is little or no variability in the telephone tariff, taking into account the fact that the price per minute of calling time differs across distance zones as well as according to when the call is made. We apply this method to data on residential demand for telephone calling time in Sweden.

1. Introduction.

There is a voluminous literature on pricing principles for a public or regulated service such as telecommunications. But our empirical knowledge of the cost and demand relations we need to know in order to implement such principles is very limited. One reason for this is, of course, that it is difficult to obtain sufficiently good data. Even if one has access to time series data for telephone demand or to cross-sectional data over regions or countries, the variability in telephone tariffs has all too often not been large enough to yield good estimates of the demand. Empirical research on telephone demand is thus typically done on data from tariff experiments (e.g., Park et al (1983)) or it uses the fact that in some countries customers are given a choice among different telephone tariffs (e.g., Train et al (1987)).

In this paper we propose a complimentary approach to the estimation of price elasticities for the demand for telephone calling time when there is little or no variability in the telephone tariff. The idea is to use the "two-dimensionality" of the tariff. The price per minute of calling time differs across distance zones as well as according to when (time of the day, time in the week) the call is made. Assuming (1) that there is no price induced substitution of telephone demand between different distance zones and (2) that telephone demand has the same structural characteristics in all distance zones, the price differentiation over time in the tariff provides an opportunity to estimate the price sensitivity of the demand for telephone calling time. We apply this method to data on residential demand for telephone calling time in Sweden.

In the next section we present our model of telephone demand and the main assumptions. The data set is described in section 3 and the estimation procedure and the results are reported in section 4.

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2. The Model.

We define a subscriber's telephone call demand as the amount of calling time he uses during some period of time, say during a week. The calling time is distributed on different distance zones as well as on different times (time of the day, time in the week) when the calls are made.

Let $x(d,t)$ denote the expected calling time in distance zone d at time period t and let $p(d,t)$ denote the price per minute of calling time in distance zone d at time t. Generally the demand $x(d,t)$ would be a function of the complete telephone tariff, i.e., of all prices $p(d,t)$, $d = 1,2,\ldots,D$ and $t = 1,2,\ldots,T$, where D is the number of distance zones and T is the number of time periods distinguished in the tariff. The estimation idea is to exploit the fact that the tariff is "two dimensional" in the sense that price (per minute) differs both across points in time (t) and across distance zones (d). Daytime calls are more expensive than evening calls, and longer distance calls are more expensive than shorter ones. We assume that the ratio between, say, calls daytime and calls in the evening would be the same across distance zones if prices did not differ between zones. In essence this means that a subscriber who contemplates making a zone d call and has to decide at which time t to make the call, takes prices for type d calls at various points in time into account, but not explicitly the distance zone d. Neither, we assume, does he take prices in other distance zones into account: different recipients of the calls he makes are not substitutes for each other. The idea is that a subscriber does not substitute a call to person A in one distance zone for a call to person B in another distance zone as a result of a price change in one of the zones. However, the longer the distance, the higher the price per minute, and hence the higher the benefit of substituting a daytime call for an evening call. This means that we expect the ratio between daytime calls and evening calls to be higher the lower the tariff (i.e., the shorter the distance). This gives us an opportunity to measure the price sensitivity of calls from cross sectional data with a *fixed* tariff.

Our second main assumption is that the demand elasticity for calling time is increasing in price. In fact, we shall follow Park *et al* (1983) and assume that the elasticity is proportional to price. If there were no cross price effects these assumptions would yield the specification $x(d,t) = a_d b_t e^{-\theta p(d,t)}$ for expected demand in zone d at time t. Although we only hope to successfully estimate the own price elasticity, we must correct for cross price effects. We assume that the income effect is negligible, and the Slutsky symmetry restrictions this imposes lead us to the specification

$$x(d,t) = a_d e^{-\theta p(d,t)}(b_t - ce^{-\theta s(d)})$$

where $s(d) = \Sigma_{\tau \neq t}\, p(d,\tau)$ and a_d, b_t, c and θ are parameters to be estimated. Actually, c could depend on d, but we restrict c to be a constant to avoid an over-parametrisation problem.

3. The Data.

The data set consists of information on total calling time divided into 24 categories for about 4000 individuals during 2 weeks: one week in June 1988 and one in September 1988. The 24 categories are defined by 4 periods of time during the week, and 6 distance zones. The time periods are (ordered according to falling prices) weekdays 8am–12pm, 12pm–6pm, 6pm–10pm, and other time. The distance zones are (ordered according to increasing prices) national trunk calls <45 km, long distance calls <45 km, 45–90 km, 90–180 km, 180–270 km and >270 km. The per minute price ranges from 12 öre to 125 öre (1 öre = SEK 0.01 $\approx$ 0.163 ¢). We have omitted local calls from the data set since we believe that the demand structure over different points in time for local calls might differ from that of long distance calls for other reasons than differences in prices.

The data were collected by the Swedish telecommunications company (Televerket) in cooperation with the Industrial Institute for Economic and Social Research in Stockholm. It has been aggregated to contain average consumption in seconds per subscriber in each of these 24 categories during the week.

4. Estimation.

Taking into account that demand is actually stochastic, the regression equation is

$$x(d,t) = a_d e^{-\theta p(d,t)}(b_t - ce^{-\theta s(d)}) + \varepsilon_{d,t},$$

where $\varepsilon_{d,t}$ is the difference between the sample mean and the moment mean of demand at time t and distance zone d. Accordingly, $E[\varepsilon_{d,t}] = 0$, $E[\varepsilon_{d,t}^2] = \sigma_{d,t}^2$ and $E[\varepsilon_{d,t}\varepsilon_{\delta t}] = 0$ if $(d,t) \neq (\delta, \tau)$. We specify the heteroskedasticity as $\sigma_{d,t}^2 = q_d r_t$, and use non-linear least squares to estimate the equation separately for the two weeks (there is a lot of seasonal variation in total demand between the two weeks: in September total demand was about 9.5% higher than in June.)* The result of the estimation is summarised in Table 1. The own price elasticity θp (p is price in öre/minute) is about the same in the two cases: $\theta = 0.013$ (s.d.$= 0.0039$) in June, $\theta = 0.016$ (s.d.$= 0.0056$) in September.

Table 1[a]

coefficient	June	September
α_1	2.06 (0.650)	2.42 (0.641)
α_2	4.24 (0.431)	4.33 (0.514)
α_3	4.62 (0.401)	4.88 (0.540)
α_4	4.85 (0.488)	5.47 (0.677)
α_5	4.37 (0.498)	5.11 (0.679)
α_6	5.05 (0.487)	4.07 (0.677)
β_2	0.0834 (0.128)	0.233 (0.184)
β_3	0.376 (0.189)	0.441 (0.252)
β_4	0.205 (0.206)	0.121 (0.275)
c	0.544 (0.767)	0.0948 (1.08)
θ	0.0129 (0.00390)	0.0162 (0.00559)
$\overline{R}^2$	0.985	0.973

[a] The estimated equation is $x = e^{\Sigma \alpha_i D_i}(e^{\Sigma \beta_j T_j} - ce^{-\theta s})e^{-\theta p}$, where D_i are dummies for the distance zones, T_j dummies for the time periods ($\beta_1 = 0$). Standard deviations are in parenthesis.

References

Park, R.M., B.M. Wetzel and B.M. Mitchell, 1983, "Price elasticities for local telephone calls", *Econometrica* 51, 1699–1730

Train, R.E., D.L. McFadden and M. Ben-Akiva, 1987, "The demand for local telephone service: a fully discrete model of residential calling patterns and service choices", *Rand Journal of Economics* 18, 109–123

* We have data also for a week in March 1988, but the equation for this week does not perform well; it gives very high standard errors, and the cross-elasticities have the wrong (but very insignificant) sign. We have found severe punch-errors in this set (due to hard ware failure) which we have corrected, but there may still remain errors that account for the bad performance, so we have left out these results.