The Welfare Impact of Competition in Fixed Telephony*

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Abstract

In Portugal, fixed telephony was liberalized in 2000. In this article, we estimate the impact on prices and consumer welfare of the liberalization process. We use a panel of household level data to estimate a structural model of demand for duration and number of calls of fixed telephony services. We focus on local and national peak period calls. The demand for duration is inelastic. Given these estimates, we perform several simulation exercises. Our results indicate that the per consumer average monthly gain of switching from the basic tariff plan of the incumbent to an alternative tariff plan is of about 70 cents. For some consumers, these gains could be as large as 2 euros.

Key Words: *Fixed Telephony, Liberalization, Prices*

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1 Introduction

In the EU countries, the telecommunications sector was a legal public monopoly for most of the twentieth century. The objective of establishing an internal market for telecommunications services led the EU to initiate the liberalization of the sector in the late 1980s.[1] The Council Resolution 93/C213/01 established the deadline of January the 1^{st} of 1998 for the liberalization of all public voice telephony services. The Resolution also granted Member States some countries an additional transition period. In Portugal the liberalization occurred in 2000. After January the 1^{st} of 2000, any firm licensed by the sectorial regulator could offer fixed telephony services, either through direct access, based on own infrastructures, or through indirect access, available for all types of calls. Table 1 gives a perspective of the Portuguese industry.

[$Table$ 1]

[$Table$ 2]

[$Figure$ 1]

The market share of the holding company *Portugal Telecom*, PT, the Portuguese telecommunications incumbent, has been falling steadily to the entrants, as shown in Table 2. These market share shifts are associated with substantial price changes, both in terms of tariff rebalancing, and in terms of price reductions, generated by the liberalization process, and illustrated in Figure 1. However, since price plans in the telecommunications industry are very complex, assessing the impact on the household welfare of these changes in nontrivial. In this article, we use a rich panel of household level data, and a structural model of demand for duration and number of calls of fixed telephony services, to evaluate the impact of prices and household welfare of the liberalization process.

The basic tariff plan of PT is the most common in our data set. Using this tariff plan as a guide, we develop a model of household demand for duration. Then, we extend this household level model to a model of population demand, that takes into account the heterogeneity of the population. We estimate this model using local and national peak

[1] The United Kingdom, Sweden, Denmark and Finland followed a different course. The liberalization occurred in 1991 in the United Kingdom; in 1993 in Sweden, in 1996 in Denmark; and in 1994 in Finland.

calls.[2] The price elasticity of the demand for duration is in the range of 0.2 to 0.3. We also develop and estimate a model of demand for number of calls. Given these estimates, we perform several simulation exercises to evaluate the household welfare gains of changing from the basic tariff plan of the incumbent, to an alternative tariff plan of *Tele 2*. The average welfare gain for the two types of calls considered is of about 70 cents. This gain could be as large as 2 euros for some households. Given that we restrict our analysis to only two types of calls at the peak period, the total gains of some households could be substantial. This might explain the fast market share growth of *Tele2*. In any case, our results are in line with those found by Economides et al. (2004) for a similar exercise.

Our research relates to Kridel, Rapaport and Taylor (2001) which present an analysis of how customers select carriers for long distance calls using a series of logit models and data on residential telephone bills with detailed call information. Using the same database and a generalized Tobit model, Kridel, Rapaport and Taylor (2002) estimate simultaneously the price elasticities of usage demand and carrier choice. Heitfield and Levy (2001) use billing information and demographic data of a cross-section of residential clients to analyze the joint distribution of the number and the duration of long distance calls. They estimate a call duration hazard model, and find that call duration is inelastic with respect to price. Chintagunta, Narayanan and Miravete (2005) develop a structural discrete-continuous model to account for both plan choice and usage decisions of households in local telephony. They incorporate into the model learning by the households about their usage patterns through observing their own calling patterns, and estimate different rates of learning for two types of available plans: fixed and measured. The results suggest that the demand for local calls is elastic with respect to price. In addition, they find that households learn very rapidly if they are on the measured plan, but learn very slowly if they are on the fixed plan. Economides, Seim and Viard (2004) adopt a similar framework to estimate a model for choice and usage of local calling plans, and investigate the welfare effects of entry of competitors into a monopoly market. The derivation presented here closely follows those presented in Moffitt (1986) and Blomquist and Hansson-Brusewitz (1990). A recent application of such a formulation to the demand for services can be found in Reiss

[2]Local calls are calls to numbers located at no more than 10 km, and national calls are calls for numbers located at more than 50 km.

and White (2005).

The remainder of this article is organized as follows. Section 2 describes the data set and presents some descriptive statistics. Furthermore, it explains the problems of the data set, and the solutions we adopted. Section 3 presents a household model of duration choice, and number of calls choice. Section 4 extends the household model to the population in a way that takes advantage of the panel nature of the data set. This section also introduces the computational methods we use to estimate the model. Section 5 presents estimates of the duration demand for local and national peak calls for customers of PT. We focused on these households because they are the most important segment of the data set. Section 6 conducts some simulation exercises. Section 7 concludes.

2 Data

2.1 Description and Descriptive Statistics

Our data set consists of monthly records of telephone usage of $1,632$ households between April 2003 and March 2004. There are four demographic variables, which are presented in Table 3. These measures are crude for the purposes of investigating the consumption patterns of telecommunications services. Figure 2 plots the histograms of the demographic variables.

$[Table\ 3]$

$[Figue\ 2]$

The consumption of telecommunications services is recorded by the remaining eight variables, which are presented in Table 4.

$[Table\ 4]$

Figure 3 shows the firms' markets shares. When our data was collected there where four major firms in the market: *PT*, *Cabovisão*, *Novis*, and *Oni*. *Tele 2*, which reached a market share of 10% in 2005, entered the market only on 2003. The remaining three firms, *AR Telecom*, *Vodafone*, and *Tmn*, had insignificant market shares. Therefore, for the remainder of this section we will focus on the four largest firms.

$[Figure\ 3]$

Calls to same prefix, i.e., local calls, and calls to another prefix, i.e. national calls, are the most important services recorded. We will, therefore, focus on them. However, the methodology developed below can be extended to the other types of calls.

Table 5 describes the average consumption patterns of calls to same prefix of clients of the four largest firms. The average number of calls is similar across firms and time. The clients of *Oni* make slightly fewer calls. The average duration of calls is similar across firms and time. The clients of *Novis* make longer calls, with a large variation across time.[3] The average cost of calls is similar across firms and time. The clients of *Novis* make slightly pricier calls.

[*Table* 5]

Table 6, describes the average consumption patterns of calls to another prefix of clients of the four largest firms. Both the average number of calls and the average duration of calls is smaller for calls to others prefixes than for calls to the same prefix. Both of these patterns are expected. Calls to other prefixes cost more. Besides, most of the relations of a household live close by.

[*Table* 6]

2.2 Problems, Solutions and Constructed Variables

The data set has three important shortcomings. The first shortcoming is that it lacks information about the firm to which a household subscribes. A randomly selected group of households suggests that households use only one firm, either through subscription of preselection. However, each month about fifty households use several firms.[4] It is impossible to know for certain to which firm such households subscribed, and which firms they used on a call-by-call basis. After a close inspection of their behavior, we assumed that these households subscribe or preselect to the firm they use the most.

The second shortcoming of the data set is that it lacks information about the tariff plan to which a household subscribes. Each firm offers a variety of tariff plans. Thus, even if a household makes all of its calls through only one firm, it is impossible to know

[3]It is unclear whether this reflects consumption patterns, or errors in the data collection process.

[4]In addition, since the data collecting company grouped the data in calendar months, rather than billing cycles, a household may appear to use more than one firm in a given month.

for sure which prices the household faces. Two files collected by *Tarifica* from February 2003 and November 2003 give information about the tariff plans of *PTC*. For *Oni* there are similar records from March 2003 and January 2004. Unfortunately, there is no similar information for *Cabovisão* and *Novis*.

The third shortcoming of the data set is that fixed-to-fixed domestic calls were grouped by prefix. However, firms price fixed-to-fixed domestic calls according to whether they are: local, regional, or national. Table 7 presents the basic tariff of PT. Sometimes a call priced according to national prices appears in the data set as a call to the same prefix. More frequently, a call classified as to same prefix is priced as a regional call.

[$Table$ 7]

The total cost function of a call with a duration of q minutes implied by the tariff plan presented in Table 7, can be formalized as:

$$P(q; p, \bar{q}) = \begin{cases} p_0, & q \leq q_1 \\ p_0 + p_1(q - q_1) & q_1 < q < q_2 \\ p_0 + p_1(q_2 - q_1) + p_2(q - q_2) & q_2 \leq q. \end{cases} \tag{2.1}$$

where $p = (p_0, p_1, p_2)$ are the marginal prices, and $\bar{q} = (q_1, q_2)$ are the kink points. For example, the peak cost function for a local call for the basic tariff plan of PT is: $p = (0.08, 0.02, 0.014)$ and $\bar{q} = (1, 10)$.

[$Figue$ 4]

Without knowing the possible total cost functions, $P(q; p, \bar{q})$, it is difficult to uniquely generate the observed total costs. Many combinations of marginal prices and kink points can yield the same cost. Fortunately, the basic tariff plans of PT and *Oni*, fit about 90% of households each month. For June and July 2003, the fit declines to 70% of the calls. We can assign the clients of PT to four tariff plans: **(i)** the basic tariff plan of PT presented in Table 7, **(ii)** a tariff plan without the 30% discount, **(iii)** tariff plan *Familia e Amigos*, and **(iv)** tariff plan *Vantagem*. Moreover, starting with September 2003, there were some free calls. Even though, there is no information regarding such plans for PT, we also allowed free calls in matching the prices.

Calls carried by *Cabovisão* are explained by a very simple pricing function: 8 cents per minute during the peak period, and 4 cents per minute during off peak, with a minimum charge period of one minute. There are no additional discounts.

The tariff plans of *Novis* are more difficult to match. It was possible to match about 90% of clients of *Novis* each month. However, these matches are based on guesses, and it is difficult to create a tariff structure as in Table 7. We identified nineteen $(p, \bar{q})$ pairs.

3 Economic Model

In this section, we develop a model of demand for telecommunications services that explains: **(i)** the choice of the number of calls, **(ii)** the choice of the duration of calls, and **(iii)** how the observed duration of a call emerges.

3.1 Utility of a Call

Utility is created when a household makes a call and the receiver responds. Both parties derive utility from the communication, but the decision to initiate the call belongs to the former. At any period, a communication need may arise. When this occurs, a household has to make two decisions: first whether to make a call, and second for how long to stay on the telephone, if she decided to make a call. households face three types of uncertainty regarding: **(i)** the *Value of the Call*, u, **(ii)** the *Value of the Conversation*, ω, and **(iii)** *Unexpected Events* or optimization errors, ϵ. When a communication need arises, the uncertainty about the value of the call, u, is resolved. However, the values of ω and ϵ remains unknown. Thus, to decide whether to make a call, a household has to form an expectation about the utility of making a call with respect to these variables. After the call is successfully initiated, the uncertainty about the value of the conversation, ω, is resolved. However, we assume that ϵ is not anticipated. Hence, although ϵ affects the final duration of a call, it does not enter into the household's optimization problem.

If a household enjoys the conversation, she remains longer on the phone. If a household does not enjoy the conversation, she remains shorter on the phone. Based on the observed value of the conversation, ω, a household chooses the duration of the call. After this decision is made, the uncertainty about ϵ is resolved, and the actual duration of the phone call is determined. Unexpected events may cause the observed duration of the call to deviate from its expected optimal value. To simplify the exposition, we suppress until section 4 the subscripts that index: the household, the call instance, and the type of call.

The utility function is given by:

$$U(q, x_0, u, \omega \,|\beta, \alpha\,) = u + (1 - \log q)q + (\beta + \omega)q + \alpha x_0, \tag{3.1}$$

where q is the duration of a call, x_0 is a composite good whose price is normalized to one, β is the *Propensity to Stay on the Phone*, and α is the *Price Sensitivity*.

A household with income Y has a budget constraint:

$$P(q) + x_0 = Y. \tag{3.2}$$

For a given household, the variables (u, ω) may vary across calls. A household observes them during the course of solving her decision problem. However, neither of these quantities is observed by the econometrician.

Specification (3.1) is restrictive. It implies log-linear demand functions. However, the inclusion of unobserved variables that change across calls gives flexibility to the model. Furthermore, given the nonlinear nature of the prices faced by the households, and the three sources of uncertainty, even this simple specification yields a complicated decision problem.[5]

In the next subsections, we solve a household's problem by working backwards. First, we solve the duration choice problem, and second the problem of whether to initiate a call.

3.2 Duration Choice

After deciding to make a call, and observing the value of the conversation, ω, a household chooses the duration of the call to maximize (3.1), subject to the budget constraint (3.2). Given cost function (2.1), and after substituting for x_0 from (3.2), the problem of a household is:

$$\max_q U(q, x_0, u, \omega \,|\beta, \alpha\,) = u + (1 - \log q)q + (\beta + \omega)q + \alpha\,[Y - P(q)]\,. \tag{3.3}$$

[5]Similar specifications were used previously. Burtless and Hausmann (1978) used a Cobb-Douglas based log-log demand function. Martins-Filho and Mayo (1993), as well as Doganoglu and Lange (2005), used a log linear specification.

Assume that $p_2 \leq p_1$. The duration demand function is:

$$\log q^*(p, \bar{q}, \beta, \omega) = \begin{cases} \beta + \omega, & \omega \leq c_1 \\ q_1, & c_1 < \omega < c_2 \\ \beta - \alpha p_1 + \omega & c_2 \leq \omega \leq c_3 \\ \beta - \alpha p_2 + \omega & \omega \geq c_3. \end{cases} \tag{3.4}$$

The cutoff points, (c_1, c_2, c_3), are:

$$c_1 = -\beta + \log q_1 \tag{3.5}$$

$$c_2 = -\beta + \log q_1 + \alpha p_1 \tag{3.6}$$

$$c_3 = -\beta + \log\left[\frac{\alpha q_2(p_2 - p_1)}{e^{\alpha(p_1 - p_2)} - 1}\right] + \alpha p_1. \tag{3.7}$$

Two comments are in order. First, if ω takes values on $[c_1, c_2]$, it is optimal to consume on the first kink. Furthermore, at $\omega = c_3$ the demand schedule jumps from the value given by the third line in (3.4) to the value given by the fourth line.

Second, the demand function (3.4) is valid under some conditions. If $q_2 \rightarrow \infty$, the budget set remains convex. Hence, the first three lines in (3.4) apply. However, the last segment, due to the discounts after q_2 minutes, implies a non-convex budget set. It is difficult to obtain a general form for the optimal duration choice in such cases. This occurs because when the household prefers to consume on $[q_2, +\infty)$ rather than on (q_1, q_2), it does not necessarily follow that she prefers to consume on $[q_2, +\infty)$ rather than on $[0, q_1]$. However, in the current formulation of the problem, one can show that for given prices and cutoff levels, if consuming on $[q_2, +\infty)$ is preferred to consuming on (q_1, q_2), then it is also preferred to consuming on $[0, q_1]$. Thus, for the purposes at hand, the demand function (3.4) remains valid for all parameters values.

Unexpected events or optimization errors, ϵ, may cause the observed duration, Q, to deviate from its optimal level, q^*:

$$\log Q = \log q^* + \epsilon \tag{3.8}$$

3.3 Likelihood of Observed Duration

Due to unexpected events, ϵ, any observed duration, Q, can be linked to an optimal duration choice, q^*, at any of the three segments, or at the kink point given in (3.4), provided that ϵ takes values on a wide enough interval. Given the distributions of ω and ϵ, one can derive the likelihood of observing a given duration. Let $g(x,p) := x - (\beta - \alpha p)$. The probability of observing Q, conditional on the pricing function and the parameters is:

$$\begin{aligned}&\mathcal{L}(Q; P(q), \theta) = \\ &\quad Pr(\epsilon + \omega = g(Q,0), \omega \leq c_1) + Pr(\epsilon = \log q_1 - \log Q, c_1 < \omega < c_2) + \\ &\quad Pr(\epsilon + \omega = g(Q,p_1), c_2 \leq \omega \leq c_3) + Pr(\epsilon + \omega = g(Q,p_2), c_3 < \omega).\end{aligned} \tag{3.9}$$

where θ is the vector of the parameters of the model.

We assume that ω follows distribution $N(0, \sigma_\omega^2)$, that ϵ follows distribution $N(0, \sigma_\epsilon^2)$, and that ω and ϵ are independent.[6]

Given the assumptions on ω and ϵ, the likelihood of observing a duration $\log Q$ can be written as:

$$\begin{aligned}\mathcal{L}(\log Q; P(q), \theta) = &\int_{-\infty}^{c_1} \frac{1}{\sigma_\epsilon \sigma_\omega} \phi\left(\frac{g(Q,0) - \omega}{\sigma_\epsilon}\right) \phi\left(\frac{\omega}{\sigma_\epsilon}\right) d\omega + \\ &\int_{c_1}^{c_2} \frac{1}{\sigma_\epsilon \sigma_\omega} \phi\left(\frac{\log q_1 - \log Q}{\sigma_\epsilon}\right) \phi\left(\frac{\omega}{\sigma_\epsilon}\right) d\omega + \\ &\int_{c_2}^{c_3} \frac{1}{\sigma_\epsilon \sigma_\omega} \phi\left(\frac{g(Q,p_1) - \omega}{\sigma_\epsilon}\right) \phi\left(\frac{\omega}{\sigma_\epsilon}\right) d\omega + \\ &\int_{c_3}^{\infty} \frac{1}{\sigma_\epsilon \sigma_\omega} \phi\left(\frac{g(Q,p_2) - \omega}{\sigma_\epsilon}\right) \phi\left(\frac{\omega}{\sigma_\epsilon}\right) d\omega\end{aligned} \tag{3.10}$$

where $\phi(\cdot)$ is the normal density function. Following Blomquist and Hannson-Brusewitz (1990), this expression can be computed as:

$$\begin{aligned}&\mathcal{L}(\log(Q); P(q), \theta) = \\ &\quad \frac{1}{\sigma_\nu} \phi\left(\frac{g(Q,0)}{\sigma_\nu}\right) \Phi(a_1) + \frac{1}{\sigma_\epsilon} \phi\left(\frac{\log x_1 - \log Q}{\sigma_\epsilon}\right) \left[\Phi\left(\frac{c_2}{\sigma_\omega}\right) - \Phi\left(\frac{c_1}{\sigma_\omega}\right)\right] + \\ &\quad \frac{1}{\sigma_\nu} \phi\left(\frac{g(Q,p_1)}{\sigma_\nu}\right) [\Phi(a_3) - \Phi(a_2)] + \frac{1}{\sigma_\nu} \phi\left(\frac{g(Q,p_2)}{\sigma_\nu}\right) (1 - \Phi(a_4))\end{aligned} \tag{3.11}$$

[6] This formulation was used by the literature studying the choice of length of employment with nonlinear tax schedules, e.g., Blomquist and Hannson-Brusewitz (1990) and Moffitt (1986), and by the literature studying the demand for electricity services with nonlinear price schedules, e.g., Reiss and White (2005).

where $\nu = \omega + \epsilon$, $\Phi(\cdot)$ is the normal cumulative distribution, and

$$a_1 = \frac{c_1 - \frac{\sigma_\omega^2 g(Q,0)}{\sigma_\nu^2}}{\frac{\sigma_\epsilon \sigma_\omega}{\sigma_\nu}}, \qquad a_2 = \frac{c_2 - \frac{\sigma_\omega^2 g(Q,p_1)}{\sigma_\nu^2}}{\frac{\sigma_\epsilon \sigma_\omega}{\sigma_\nu}},$$

$$a_3 = \frac{c_3 - \frac{\sigma_\omega^2 g(Q,p_1)}{\sigma_\nu^2}}{\frac{\sigma_\epsilon \sigma_\omega}{\sigma_\nu}}, \qquad a_4 = \frac{c_3 - \frac{\sigma_\omega^2 g(Q,p_2)}{\sigma_\nu^2}}{\frac{\sigma_\epsilon \sigma_\omega}{\sigma_\nu}}.$$

Expression (3.11) is the likelihood of observing $\log Q$. The likelihood of observing Q is:

$$\mathcal{L}(Q; P(q), \theta) = \frac{1}{Q}\mathcal{L}(\log \ Q; P(q), \theta). \tag{3.12}$$

For each household we have T call observations, for which we know the duration and the cost. After collecting in $\mathbf{Q}$, and the corresponding prices in $\mathbf{P}(\mathbf{Q})$, the likelihood of these T observations is:

$$\mathcal{L}(\mathbf{Q}; \mathbf{P}(\mathbf{Q}), \theta) = \prod_{t=1}^{T} \mathcal{L}(Q_t; P(Q_t), \theta). \tag{3.13}$$

The log-likelihood is then given by:

$$\mathcal{LL}(\mathbf{Q}; \mathbf{P}(\mathbf{Q}), \theta) = \log \mathcal{L}(\mathbf{Q}; \mathbf{P}(\mathbf{Q}), \theta) = \sum_{t=1}^{T} \log \mathcal{L}(Q_t; P(Q_t), \theta). \tag{3.14}$$

3.4 Call Choice

Given the model of duration choice, one can compute the value of a call net of value of the conversation. Rewrite the expected value of the maximum utility function (3.1) over ω as[7]:

$$EU(u) = u + E[V(P(q))] + \alpha Y, \tag{3.15}$$

with

$$E[V(P(q))] = E_{[\omega]} \left[q(\omega) \left(1 - \log q(\omega)\right) + (\beta + \omega) q(\omega) - \alpha P(q(\omega)) \right]. \tag{3.16}$$

When no call is made the utility is αY. Thus, it is optimal to make a call if:

$$u + E[V(P(q))] + \alpha Y \geq \alpha Y,$$

[7] Recall that ϵ is not anticipated. Hence it does not enter into the expected ex ante benefit calculation. However, clearly the ex post benefit of a call is affected by the realized value of ϵ.

or alternatively, if $u > -E[V(P(q))]$.

Next we derive how the optimal choice of whether to make a call may yields the total number of observed calls. Assume that there are N possible occasions to make a call. In addition, assume at each such occasion the receiving party is available with probability ρ. Given this process, the probability of observing k calls is:

$$P(k) = \begin{pmatrix} N \\ k \end{pmatrix} \rho\big[1 - F(-E[V(P(q))])\big]^k \big[\rho F(-E[V(P(q))])\big]^{N-k}, \qquad k = 0, \ldots, N \tag{3.17}$$

where $F(\cdot)$ is the cumulative distribution function of the value of a call u. Expression (3.17) is a variant of the familiar binomial distribution.

Consider the limit of this process when: **(i)** the number of possible call occasions approach infinity, i.e. $N \to \infty$, **(ii)** the probability of a need communication arising at an instant at which the receiver is available approaches zero, i.e. $\rho \to 0$, and **(iii)** there is a constant number of communication needs in a given interval of time, i.e. $N\rho = \lambda$. It is well know that under these circumstances, the probability distribution (3.17) approaches the Poisson distribution:

$$P(k) = \frac{e^{-\lambda\big[1-F(-E[V(P(q))])\big]}\big[\lambda F(-E[V(P(q))]))\big]^k}{k!}. \tag{3.18}$$

Given an estimate of $E[V(P(q))$, parameter λ and the parameters of the distribution of u can be estimated by maximum likelihood.

4 Econometric Implementation of the Population Model

In this section, we extend the household choice model developed in section 3 to the population. We do this because of the lack of enough data at the household level. As indicated by Table 5, on average each household makes 25 calls per month. It is impossible to estimate the parameters of a monthly household model with any precision.[8] A way to overcome this difficulty is to take advantage of the panel nature of the data set. The household parameters can be assumed to be fixed within a month, but to vary in the population according to a distribution. Thus, instead of estimating parameters for each household, one can estimate the parameters for the population distribution. This reduces the dimensionality of the problem drastically.

4.1 Duration Model for the Population

Index households with subscript $i = 1, ..., N$. The vector of parameters of household i, θ_i, belongs to Θ_i, and follows distribution $F(\theta_i \mid \pi)$, where π is a vector of parameters of the population distribution. The likelihood of observing a sequence of calls of household i, conditional on parameters θ_i, is given by (3.13). We do not know the values of the parameters of the households, but we know that they are drawn from $F(\theta_i \mid \pi)$. Thus, we can write the unconditional likelihood of observing a sequence of T_i calls of household i as:

$$\mathcal{L}(\mathbf{Q}_i; \mathbf{P}(\mathbf{Q}_i), \theta) = \int_{\theta_i \in \Theta_i} \prod_{t=1}^{T_i} \mathcal{L}(Q_{it}; P(Q_{it}), \theta_i) dF(\theta_i \mid \pi). \tag{4.1}$$

The unconditional log-likelihood of observations from N households is:

$$\mathcal{LL}(\mathbf{Q}; \mathbf{P}(\mathbf{Q}), \theta) = \sum_{i=1}^{N} \log \mathcal{L}(\mathbf{Q}_i; \mathbf{P}(\mathbf{Q}_i), \pi). \tag{4.2}$$

We assume independence between the distributions of the parameters of a household. After many exploratory estimations we decided to assume that β follows distribution $N(\mu_\beta, \sigma_\beta)$, α follows distribution $Exp(\mu_\alpha)$, while both σ_ϵ and σ_ω are constant in the population. The integral in (4.1) is over two dimensions. Hence, it can be evaluated through numerical integration.

[8] It is useful to estimate monthly models. First because behavior may vary over time. Second, because the size of the data set is too large for the methods we will introduce below.

This methodology identifies the population density of household specific parameters, $F(\theta_i \mid \pi)$. It is possible to find where the tastes of each household lie in this distribution conditional on their choices. The conditional distribution of each household's parameters can be calculated as:

$$h(\theta_i \mid \mathbf{Q}_i, \pi) = \frac{\mathcal{L}(\mathbf{Q}; \mathbf{P}(\mathbf{Q}_i), \mid \theta_i) f(\theta_i \mid \pi)}{\mathcal{L}(\mathbf{Q}; \mathbf{P}(\mathbf{Q}_i), \mid \theta_i)}, \tag{4.3}$$

by using the Baye's rule, as shown in Revelt and Train (1999). This results in a distribution for each household given its choices.

4.2 Number of Calls Model for the Population

Given a set of parameters of a household, one can compute the expected value of a call, $E[V(p(q)]$, given in (3.16). The methodology of section 4 delivers parameters of the population distributions. But based on the choices of a household, one can derive a household specific posterior distribution of its parameters by using (4.3). One can draw values from this distribution.[9] Then, for each realization of the parameters, we compute $E[V(P(q))]$, which yields a set of realizations on this object. We then fit a kernel density to this realized distribution of $E[V(P(q))]$. Finally, we select as our estimate the mode of that distribution, the most likely value. Denote by S_i, the household specific estimate of the expected value of a call constructed this way, i.e.,

$$S_i = \text{mode}\left\{E[V(P(q)) \mid h(\theta_i|\mathbf{Q}_i, \pi)]\right\}.$$

If $u > S_i$, the household decides to make a call. Variable u follows the distribution $N(0, \sigma_u^2)$. This implies that the values of a call of all households are drawn from the same distribution. We also considered the mean of the distribution. However, this led to multicollinearity problems.

We assume that the mean of the Poisson distribution, which governs the arrival process of communication needs, is a function of demographic and seasonal variables:

$$\log(\lambda_i) = X\gamma + \kappa_i,$$

where λ is the population mean of the average number of arriving communication needs, X is a vector of demographic and seasonal variables, γ a vector of parameters which measures

[9] By using acceptance sampling, importance sampling, or the metropolis Hastings algorithm.

the importance of the demographic and seasonal variables, and κ_i is an household specific term that affects the mean arrival rate of communication needs. That is, each household is assumed to have a household specific propensity to receive communication needs. Variable κ_i follows the distribution $N(\mu_\kappa, \sigma_\kappa^2)$.

Given the specification of λ_i and S_i, the average rate of calls a household makes is: $\lambda_i \left[1 - \phi(-\frac{S_i}{\sigma_u})\right]$. One can estimate the parameters of the process of the number of calls by maximum likelihood.

5 Estimation Results

5.1 Estimates of the Duration Model for the Population

5.2 Local Peak Calls

In the estimation, we used data on local and national peak period calls, from September 2003 and March 2004, and for the basic tariff of PT. The model we estimate for the demand for duration has two random coefficients associated with the propensity to stay on the phone and price sensitivity parameters, (β, α), which follow $(N(\mu_\beta, \sigma_\beta), Exp(\mu_\alpha))$.The value of the conversation and the unexpected event parameters, σ_ω and σ_ϵ, are assumed to be the same for all households.[10] The vector of parameters for this model is $\pi = (\mu_\beta, \sigma_\beta, \mu_\alpha, \sigma_\epsilon, \sigma_\omega)$.

We estimated the model for the local calls for the peak period with the customers of PT who made at least 4 local calls. There are 470 such households that made 7,300 per month , or a total of 51,013 calls. The prices were measured in cents for these estimated models. The results are reported in Tables 8-9.

[$Table$ 8]

[$Table$ 9]

For each month, all estimated parameters are significant. There is a large variation in the population in the propensity to stay on the phone, β, and the price sensitivity, α.

[10] In other words, we assume that the value of the conversation, ω, and the unexpected event, ϵ, of all households are drawn from the same distribution. Initially we estimated models where all parameters were random. The variance estimates of ϵ and ω turned out to be very small.

The mean value of the price parameter is about 0.14. If the pricing function had no kinks, then the demand for duration of a household would be: $\log(q) = \beta - \alpha p + \omega + \epsilon$. The price elasticity of demand, in this case, would be given by αp. The mean parameter estimate implies a price elasticity of about 0.28 at the price of 2 cents. This elasticity value is in line with the literature, for example with Heitfeld and Levy(2001), who found that the demand for duration is inelastic with respect to price.

5.3 National Peak Calls

For the estimation of the model for national peak period calls, we also used data from the period between September 2003 and March 2004. We estimated a model with the same specification as for the local peak period calls. There is one important difference on the data, however. Consumers make substantially less national calls than local ones.[11] We estimated the model for national peak period calls with the customers of PT who made at least 2 national calls. There are 200 such households, that 800 calls per month or a total of 5,566 calls. The results are reported in Tables 10-11.

[$Table$ 10]

[$Table$ 11]

All parameter estimates are significant, except for σ_ω. This implies that the optimal duration for national calls is constant across call occasions. The variation in the duration of the calls of each household is due only to unanticipated shocks. The non-significance could also be due to the fact that many households make only a few calls each month. The cross section variance in duration is completely explained by the variation in β, which is comparable to the variation for local peak period calls. However, the mean of β is more than twice as large compared to local calls. This implies a higher average duration for national calls. A brief inspection of Tables 5 and 6, confirms that this is indeed the case for local and long distance calls carried by PT. The mean price sensitivity parameter is much smaller compared to that of local calls, as its average over the seven months is about 0.031. However, the implied price elasticity based on a demand function when the price

[11]The identification of the variances of ω, σ, and β, hinges on existence of many observations of the same household. This turned out to be a challenge for the national call data.

function has no kinks is 0.23, which is it is very similar to local calls, and suggests an inelastic demand for duration for national calls.

5.4 Estimates of the Number of Local and National Calls Model for the Population

We estimated the demand for the number of calls for peak period calls with data from September 2003 to March 2004. The construction of the net surplus variable, S_i, is based on the estimates from the duration models for the same type of calls, during the same period, presented in Tables 8-9 for local peak period calls, and Tables 10-11 for national peak period calls. During this period, 718 households made 3,269 local calls, and 395 households made 1,139 national calls, yielding an average about 15 local calls and 4 national calls per month.

We made use of all the four demographic variables present in the data set. Since there is significant increase in the average number of calls in December, we also included a December dummy. The rest of the specification follows what we described in section 4.2. Tables 12 and 13 present the results.

[$Table$ 12]

For the model for the number of local peak period calls, we find that two demographic variables help explain the variation in the cross section in a significant manner. First, the households located in Lisbon and in the greater oPorto area make more calls as indicated by the negative γ_{Region} estimate. This could be due to either more people living in these areas, or these ares being wealthier. Furthermore, age affects the number of local calls considerably. This may be due to the fact that households with older largest income earners are more likely to be larger families and with adolescents. There also is a significant Christmas effect. In December, the number of calls made by households seems to increase in a substantial manner. There is large variation in the idiosyncratic propensity to make calls, as indicated by the significant estimate of σ_κ. The effect of net surplus, S_i, is significant, but as indicated by the large estimate for σ_u, it does not play a very large role. This could be interpreted either as a large variance across call occasions, or may indicate a lack of sufficient variation in this variable. We will discuss this issue further, after discussing the estimates of the demand for the number of national peak period calls.

[$Table$ 13]

The estimated parameter values from table 13 indicate that three demographic variables help explain the variation in the cross section differences in the number of national calls in peak period in a significant manner. First, the households with higher schooling make more national calls. The effect of schooling could be explained by largest income earner with higher education having higher incomes. Furthermore, the households located outside of the Lisbon and the greater oPorto area make more national calls, as indicated by the small but positive γ_{Region} estimate. This once again could simply be due to the larger size of the population in these areas. That is, everyone has a relative living in two centers of population. Moreover, age seems to affect the number of national calls considerably for possibly the same reasons as local calls. There also is a significant Christmas effect. There is substantial, but somewhat smaller, variation in the idiosyncratic propensity to make calls, as indicated by the significant σ_{κ} estimate. The mean value of the idiosyncratic propensity to make calls, μ_{κ}, is significantly less that its corresponding value for local calls. Given the large difference in average number of calls for both categories, this is the expected result.

The effect of net surplus, S_i, turns out to be significant. The large variance of u, and its non significance, could be also due to the fact that tariffs faced by the households remain constant over time. This implies that the estimated surpluses would also remain constant over time. Thus, the term due to the effect of the surplus, S_i, in modeling the mean number of calls is very similar to the idiosyncratic propensity to make calls. Given that this is present in the model, and accounts for quite a bit of the cross sectional variance, the estimated effect of the net surplus may turn out to be small and non significant. Indeed, multicollinearity problems did not allow us to estimate a mean parameter for the distribution of u.

6 Policy Simulations

In this section, we measure the expected effect, for local and national calls during the peak period, of a change from the basic tariff plan of PT to the tariff plan of *Tele 2*. The purpose of this exercise is twofold. First, we want to illustrate the type of exercises one can perform with the model we developed. Second, we want to quantify the impact on prices and household welfare of the liberalization process. This last aspect explains our choice of the tariff plan of *Tele 2*. It is a cheapest tariff plan available. Besides, as Figure 1 shows, the usage costs of fixed telephony in Portugal only changed substantially after *Tele 2* entered the market in 2003.

We computed the expected surplus variable, S_i, for each household with the methodology described in section 4.2, using the estimates of the duration model for the peak period for the months from September 2003 to March 2003 of Tables 8-9 and 10-11. The model of the demand for the number of calls for the population was estimated with these values.

One can obtain the monetary equivalent of the surplus by normalizing with respect to α. Thus, we also computed the mode of the distribution of $\frac{S_i}{\alpha}$ using the distribution of household specific parameters. Figure 5 presents a histogram of average monetary values over the seven month period for local calls on the top panel and for national calls on the bottom panel. The mean value or surplus in the population of a local call is 40 cents. The mean value of a national call is 2.75 euros. This high value is partly due to the low price sensitivity parameter for long distance calls. However, as indicated by the larger value of μ_β, national calls have inherently a higher value. Consumers prefer talking longer when they make long distance calls. Furthermore, given the rarity of these calls, the transmitted information is likely to be higher.

$[Figure\ 5]$

Next we performed the same exercise using two tariffs of *Tele 2*. First we used the tariff for local calls. The setup duration is of 120 seconds, at a cost of 8 cents, the same as in the tariff of PT. Every additional minute is charged at 0.6 cents, which is cheaper than the basic tariff of PT. Secondly, we used the tariff for long distance calls. The setup duration is 10 seconds, the same as for the PT tariff, at a cost of 8 cents. Each additional minute costs 3.3 cents.

We computed the S_i values based on these tariffs of *Tele 2*, but using the estimated preference parameters. We present first the results for the local peak period calls. For each consume, we estimate an average value of a call for the seven month period. The estimates of the value of a call are similar to those obtained using the basic tariff of PT. Thus, it is most informative to report the difference. In Figure 6, we plot the histogram of the difference between the expected monetary value of a call made through the tariff plan of *Tele 2* and the basic tariff plan of PT. Considering only the difference in surplus per call, all households are better off under the tariff plan of *Tele 2*. The average gain in the population is 2.02 cents. Given that the distribution is somewhat asymmetric, it is informative to consider a few percentiles of the population distribution of the surplus gain. The median, the 75%, and the 95 % percentiles are 1.93, 2.38 and 3.17, respectively. If one assumes that the change to the tariff of *Tele 2* has no effect on number of calls a household makes, the average estimate implies a monthly gain of 30 cents. For the households on the right tail of the surplus gain distribution, the monthly gain could be as high as 50 cents. Besides, this gain is only for local peak period calls.

$[Figue\ 6]$

We performed the same exercise for national calls using the corresponding tariff. In Figure 7, we present a histogram of the estimated surplus gains if consumers placed their calls using the alternative tariff of *Tele2* . The average gain in the population is 11.1 cents. The median, the 75%, and the 95 % percentiles of the population distribution of the surplus gains are 10.8, 12.5 and 15.5 cents, respectively. If one assume that the change to the tariff of *Tele 2* had no effect on number of calls a household makes, the average estimate a monthly gain of 55 cent. For households on the right tail of the surplus gain distribution, the monthly benefit could be as high as 80 cents. If the households on the right tail make more calls than the other households, this is a conservative estimate, and the gains for national peak calls could be of a few euros.

$[Figure\ 7]$

The increase in the surplus per call may lead to an increase in the average number of calls. We computed first the expected number of calls based on the basic tariff plan of PT using the estimates from model of the demand of the number of calls, given in Table 12.[12] Figure 8 presents the histogram of the average difference in the expected number of

[12]We drew from the conditional household distribution of the random parameter κ_i, and computed the mode of the realizations of mean value of a Poisson distribution.

local peak period calls for the seven month period, if consumers used the alternative tariff plan of *Tele2* instead of the basic tariff plan of PT. The impact of the tariff change on number of calls is minimal. The mean of the Poisson distribution does not increase even by one unit. This is to be expected. We had already found that the impact of the surplus of a call on the demand for the number of calls is not very high. This does not necessarily mean that households do not care about the value of calls. As we argued above, this could be due to the fact that the mean value of a local call did not change much in the period considered. The prices households face certainly remained the same. Thus, given this little variation on expected surplus of call, it might be that the effect of prices, via their effect on the surplus, are not identified with the current data. This exercise performed on the national calls peak period calls led to the same outcome. The results are hence omitted.

$[Figure\ 8]$

Given the slight difference in the mean number of calls for both local and national peak period calls, one can evaluate the expected welfare gain of the alternative tariff as:[13]

$$\begin{aligned} \text{Welfare Gain} &= \text{Expected number of calls with the basic tariff plan of } PTC \times \\ &\quad \text{Expected welfare gain per call.} \end{aligned}$$

Figure 9 presents a histogram of these gains for local peak period calls on the top panel, and for national peak period calls on the bottom panel. Table 14 presents several summary statistics of these gains.

$[Figue\ 9]$

$[Table\ 14]$

[13]We approximate $Welfare\ Gain = Expected\ number\ of\ calls\ with\ the\ new\ tariff \times Welfare\ per\ call\ with\ the\ new\ tariff - Expected\ number\ of\ calls\ with\ the\ old\ tariff \times Welfare\ per\ call\ with\ the\ old\ tariff$, with $WelfareGain = Expected\ number\ of\ calls\ with\ the\ old\ tariff \times Welfare\ per\ call\ with\ the\ new\ tariff - Expected\ number\ of\ calls\ with\ the\ old\ tariff \times Welfare\ per\ call\ with\ the\ old\ tariff = Expected\ number\ of\ calls\ with\ the\ old\ tariff * (Welfare\ per\ call\ with\ the\ new\ tariff - Welfare\ per\ call\ with\ the\ old\ tariff)$.

7 Conclusions

We developed a household level model of demand for duration and number of calls. Based on data from the period between September 2003 and March 2004, we estimated the model for local and national calls for the peak period carried by the Portuguese telecommunications' incumbent. The duration demand model was estimated monthly. Assuming linear pricing, the price elasticity of the demand for duration ranges from 0.2 to 0.3. These estimates are in line with the literature. Households prefer to stay longer on the phone, and are less sensitive to price, for national calls than for local calls. Furthermore, unanticipated events have a large impact on the duration of a call.

Using the model of demand for duration we computed the expected net utility of a call, and used it as an input for the estimation of the demand for the number of calls. The effect of the surplus on the number of calls is not very strong. This could be due to the fact that a household's surplus does not change very much during the estimation period, and hence is quite closely related to the individual propensity to make calls.

We found a few interesting properties of the demand for the number of calls regarding demographics and seasonal variables. Households with older largest income earners tend to make more calls. This could be due to the fact that such households comprise a larger number of individuals. We also found that households residing in Lisbon and the greater oPorto area make more local calls than the rest of the population. However, they make fewer national calls. There is also a significant Christmas effect that increases the number of calls in December.

Using the estimated models we performed a policy experiment. We computed the expected consumer surplus of the basic tariff plan of the incumbent, and of the tariff plan of an entrant. Then, we computed the expected gain from switching from the first to the second tariff plan. The gain is on average of 2 cents per local call in the peak period, and of 10 cents per national call in the peak period. We also investigated the effect of the switch in tariff plans on the demand for the number of calls. The demand for number of calls does not respond much to the changes in tariff plans. We then computed the monthly net gain of such a change. The average monthly gain per household on local calls in the peak period is of 30 cents, while the average gain per household on national calls in the peak period is of 40 cents, which together imply an average gain per household of 70 cents. Note, however, that at the right tail of this distribution the benefits could amount to 2 euros. Since we analyzed only two types of calls at the peak period, the gains aggregated over all types of calls and time periods could be substantial.

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9 Tables

1981	creation of sectorial regulator, *ICP-ANACOM*
1987	beginning of digitalization of the *PSTN*
1994	group *PT* formed
	assignment of licenses for *Cable TV*
1997	basic Telecommunications Law
1998	full liberalization of the telecommunications industry in the *EU*
1999	Law 458/99 of the scope of Universal Service
	full digitalization of *PSTN*
	broadband access to Internet through *Cable Modem*
2000	full liberalization of the telecommunications industry in Portugal
	introduction of carrier pre-selection
2001	introduction of number portability
	local loop unbundling
	broadband access to Internet through *DSL*
2003	implementation of the 99 Revision
Souce: Authors	

Table 1: Chronology of the Telecommunications Sector in Portugal

	2000	2001	2002	2003	2004	2005
Group PT	98.2	89.7	82.6	83	78.7	78.2
Oni	0.6	4.1	5.9	5.9	2.8	
Novis	0.4	2.2	4.4	3.7	5.7	
AR Telecom	0.1	0.8	0.7	0.8	0.4	
Cabovisão	0.0	1.2	3.9	4.0	4.0	
Vodafone	0.1	0.9	1.8	1.9	2.7	
Tele 2	0.0	0.0	0.0	0.0	5.7	10
Source: Authors						

Table 2: Market Shares of Residential Fixed Telephony

Table 3: Definition of the Demographic Variables

Variable	Levels	Definitions
social class	five levels	A, B, C1, C2, D
schooling of the largest income earner in the household (lieh)	eight levels	1 - illiterate/incomplete 4th grade 2 - 4th grade 3 - 6th grade 4 - 9th grade 5 - 12th grade 6 - incomplete bachelor's degree 7 - bachelor's degree 8 - other
region the household is located	six levels	1 - Greater Lisbon 2 - Greater oPorto 3 - Northern Coast 4 - Central Cost 5 - Northern Interior 6 - South
age of the lieh	integer variable	19 - 92

Table 4: Definition of Call and Subscription Variables

Variable Name	Levels	Definitions
value of subscription	Euros	Fixed fee
call counter of household	integers	cumulative number of calls in the billing month
value of call without VAT	Euros	total cost of the call
Date of the call	Date	Day:Month:Year
duration of the call	Time	Minutes:Seconds
firm that originated the call	8 codes	111 - Cabovisão 151 - PTC 152-Novis 153 - Oni 154 - Jazztel 157 - Toq (Vodafone) 158 - Tele 2 159 - TMN
time of the call	Time	Hour:Minute:Second
type of the call	9 Codes	1 - mobile networks 2 - same prefix 3 - different prefixes 4 - international 5 - services 6 - 808/707 7 - Data 8 - Others 9 - SMS

Table 5: Calls to Same Prefix:(Average number, Average Duration, Average Cost)

	111	151	152	153
200304	(24,7.023,0.316)	(26,5.197,0.205)	(27,6.242,0.193)	(28,3.764,0.188)
200305	(25,5.389,0.207)	(25,2.764,0.226)	(26,18.254,0.412)	(28,7.305,0.210)
200306	(25,3.795,0.149)	(25,2.366,0.274)	(26,22.754,0.471)	(28,5.384,0.228)
200307	(26,3.677,0.179)	(26,3.309,0.253)	(29,14.388,0.344)	(27,6.056,0.154)
200308	(21,3.109,0.153)	(22,6.472,0.165)	(22,17.034,0.391)	(23,7.503,0.334)
200309	(25,6.088,0.286)	(25,5.304,0.185)	(26,8.400,0.190)	(28,4.987,0.199)
200310	(25,4.989,0.227)	(25,7.950,0.254)	(26,12.991,0.297)	(29,5.488,0.363)
200311	(23,4.709,0.210)	(23,3.069,0.169)	(21,13.384,0.312)	(28,3.828,0.216)
200312	(24,5.432,0.296)	(29,5.414,0.161)	(25,9.745,0.298)	(32,3.448,0.265)
200401	(23,4.877,0.215)	(23,3.931,0.122)	(24,5.215,0.245)	(28,3.499,0.343)
200402	(21,6.351,0.255)	(21,6.966,0.273)	(22,4.383,0.265)	(27,4.415,0.288)
200403	(20,3.435,0.185)	(22,5.083,0.163)	(26,3.708,0.191)	(28,4.965,0.259)

Table 6: Calls to Different Prefix:(Average number, Average Duration, Average Cost)

	111	151	152	153
200304	(7,5.780,0.245)	(6,4.205,0.160)	(5,4.614,0.123)	(6,3.172,0.150)
200305	(7,4.706,0.172)	(6,2.280,0.193)	(5,15.277,0.345)	(6,6.753,0.183)
200306	(8,3.266,0.136)	(6,1.957,0.225)	(4,15.863,0.316)	(6,5.558,0.259)
200307	(7,3.620,0.176)	(6,2.736,0.204)	(5,11.637,0.283)	(7,4.584,0.130)
200308	(6,2.992,0.153)	(6,4.598,0.123)	(5,9.975,0.238)	(7,6.283,0.302)
200309	(7,5.612,0.275)	(6,4.151,0.150)	(5,6.162,0.144)	(7,4.581,0.202)
200310	(8,4.007,0.185)	(5,5.360,0.189)	(4,9.946,0.225)	(6,4.981,0.343)
200311	(9,3.807,0.173)	(5,2.402,0.148)	(5,7.288,0.167)	(7,3.455,0.142)
200312	(10,5.314,0.287)	(6,4.119,0.132)	(7,6.334,0.226)	(8,2.720,0.220)
200401	(9,4.201,0.184)	(5,2.938,0.090)	(5,4.265,0.203)	(7,2.834,0.358)
200402	(8,5.052,0.216)	(5,4.601,0.206)	(4,3.275,0.195)	(4,4.567,0.214)
200403	(9,3.745,0.199)	(5,3.882,0.129)	(6,2.287,0.119)	(5,3.896,0.184)

Table 7: Basic *PTC* Tariff from February and November 2003

Coverage	Minimum charge	Min. Charge Duration (secs)	Rate 1[a]	Rate 2[a]
Local (< 10 km)	0.0800	60	0.0200	0.0100
Regional (10-50 km)	0.0800	20	0.0485	0.0200
National (> 50 km)	0.0800	10	0.0738	0.0300

Notes:

a. Time zones
   - Rate 1 0900–2100 Monday - Friday .
   - Rate 2 all other times.

b. Per second billing applies after the minimum charge time.

c. There is a discount of 30% after the initial 10 minutes.

d. There is a minimum charge of one minute, thereafter per second billing applies.

Table 8: Population Parameter Estimates for in September-December 2003: Local Peak Calls

	September 2003		October 2003		November 2003		December 2003	
Parameter	Estimate	St. Err.	Estimate	St. Err	Estimate	St. Err.	Estimate	St. Err.
μ_β	0.4933	0.03897	0.5181	0.03601	0.5274	0.04102	0.4450	0.03181
σ_β	0.4481	0.02491	0.3712	0.02494	0.4219	0.02717	0.3414	0.02232
μ_α	0.1218	0.02397	0.1251	0.02226	0.1405	0.02545	0.1289	0.02077
σ_ϵ	0.8966	0.06361	0.9106	0.05647	0.9271	0.05835	0.7935	0.05979
σ_ω	0.8399	0.07337	0.8091	0.07034	0.7444	0.08317	0.9172	0.05460
Likelihood	-16698.3934		-15827.9925		-13677.3804		-16899.5241	
# of Obs.	8461		8002		6968		8871	
# of Individuals	502		486		477		493	
Max Obs./Ind.	133		122		167		183	

Table 9: Population Parameter Estimates for in January-March 2004: Local Peak Calls

	January 2004		February 2004		March 2004	
Parameter	Estimate	St. Err.	Estimate	St. Err	Estimate	St. Err.
μ_β	0.5280	0.04270	0.5247	0.04408	0.5168	0.03875
σ_β	0.4131	0.02797	0.4305	0.02948	0.4100	0.02650
μ_α	0.1477	0.02756	0.1634	0.02989	0.1614	0.02630
σ_ϵ	0.9413	0.05899	0.8955	0.05772	0.8143	0.06477
σ_ω	0.8032	0.07808	0.8710	0.06642	0.8988	0.06450
Log-Likelihood	-12626.2627		-11437.0465		-12855.0947	
# of Obs.	6322		5790		6599	
# of Individuals	428		428		455	
Max Obs./Ind.	92		74		79	

Table 10: Population Parameter Estimates for in September-December 2003: National Peak Calls

	September 2003		October 2003		November 2003		December 2003	
Parameter	Estimate	St. Err.	Estimate	St. Err	Estimate	St. Err.	Estimate	St. Err.
μ_β	1.1989	0.06933	1.1769	0.07437	1.2095	0.08164	1.1873	0.06588
σ_β	0.4382	0.05758	0.4114	0.06983	0.4992	0.06641	0.3966	0.05068
μ_α	0.03259	0.007149	0.03542	0.007964	0.03621	0.008414	0.02904	0.007058
σ_ϵ	0.9510	0.1069	1.0017	0.1521	0.9957	0.08651	0.9831	0.1624
σ_ω	0.2356	0.4224	0.2718	0.5513	0.1868	0.4287	0.1862	0.8488
Likelihood	-2183.7366		-1963.2232		-1778.2207		-2505.6734	
# of Obs.	908		809		719		1030	
# of Individuals	220		205		200		254	
Max Obs./Ind.	29		35		34		27	

Table 11: Population Parameter Estimates for in January-March 2004: National Peak Calls

	January 2004		February 2004		March 2004	
Parameter	Estimate	St. Err.	Estimate	St. Err	Estimate	St. Err.
μ_β	1.1663	0.07907	1.0280	0.07480	1.1727	0.07032
σ_β	0.3910	0.07109	0.3348	0.07501	0.2541	0.07217
μ_α	0.03173	0.008607	0.02977	0.008347	0.02498	0.008282
σ_ϵ	1.0149	0.1624	0.9994	0.3293	1.0461	0.4372
σ_ω	0.2520	0.6418	0.2751	1.1907	0.2361	1.9325
Log-Likelihood	-1797.1382		-1525.9912		-1822.3570	
# of Obs.	729		654		717	
# of Individuals	184		173		158	
Max Obs./Ind.	21		22		31	

Table 12: Population Parameter Estimates for the Random Coefficients Poisson Number of Calls Model for Local Peak Calls

Parameter	Estimate	Standard Error
$\gamma_{SocialClass}$	-0.01958	0.04642
$\gamma_{Schooling}$	0.03669	0.02813
γ_{Region}	-0.03672	0.01628
γ_{Age}	0.5057	0.2499
$\gamma_{Christmas}$	0.1540	0.01201
σ_u	29.9236	12.7007
μ_κ	2.7919	0.3100
σ_κ	0.6942	0.02031
Log-Likelihood	-12154.3545	
# of Obs.	3269	
# of Individuals	718	
Max Obs./Ind.	7	

Table 13: Population Parameter Estimates for the Random Coefficients Poisson Number of Calls Model for National Peak Calls

Parameter	Estimate	Standard Error
$\gamma_{SocialClass}$	0.06399	0.05353
$\gamma_{Schooling}$	0.09420	0.03136
γ_{Region}	0.05913	0.01836
γ_{Age}	0.5369	0.2837
$\gamma_{Christmas}$	0.1211	0.03834
σ_u	34.1275	42.5694
μ_κ	0.7266	0.3556
σ_κ	0.4888	0.02520
Log-Likelihood	-2770.7965	
# of Obs.	1139	
# of Individuals	395	
Max Obs./Ind.	7	

Table 14: Summary Statistics of Estimated Welfare Gain Using the Alternative *Tele2* Tariff

Type of Call	Mean	Median	75% percentile	95% percentile
Local Peak	28.91	20.07	34.91	86.89
National Peak	42.33	33.83	52.35	104.60
Sum	71.24	53.89	87.261	191.49

10 Figures

Figure 1: OECD National PSTN Basket

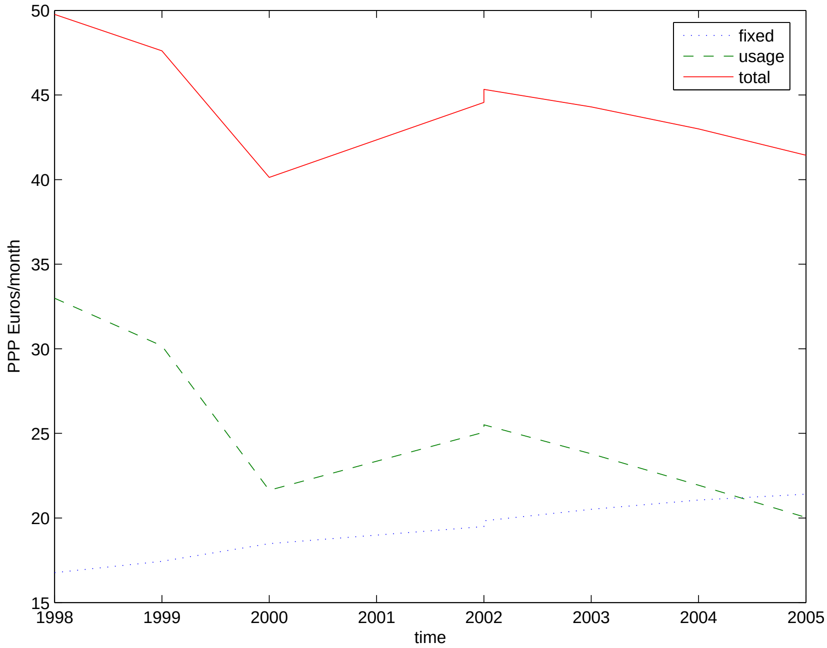

Figure 2: Histograms of the demographic variables

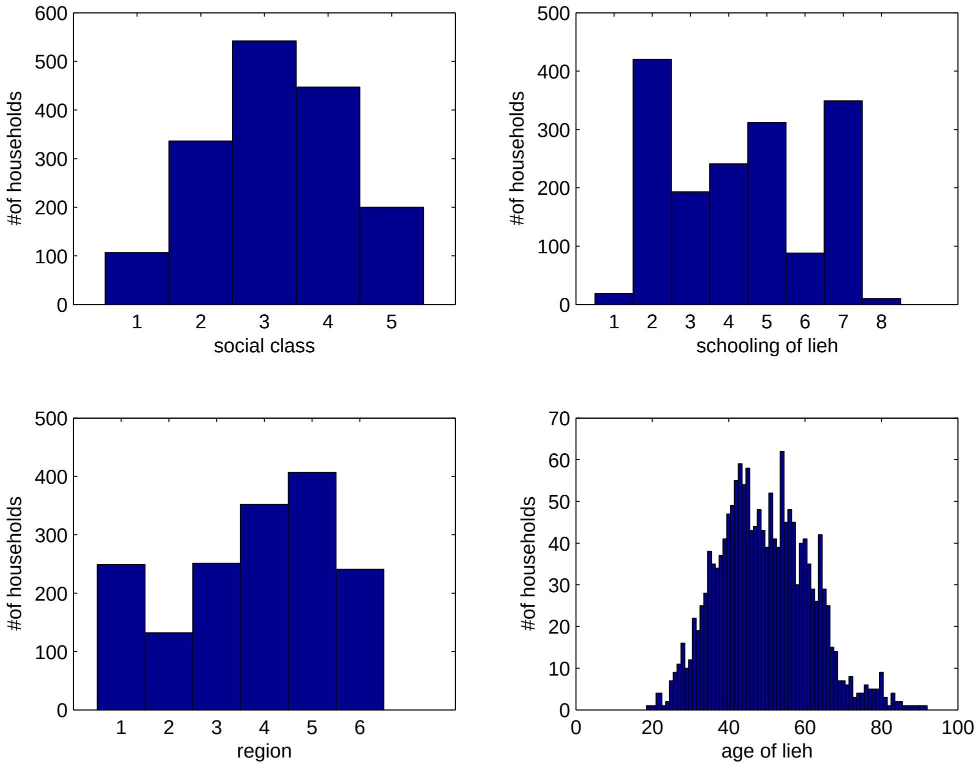

Figure 3: Market Shares

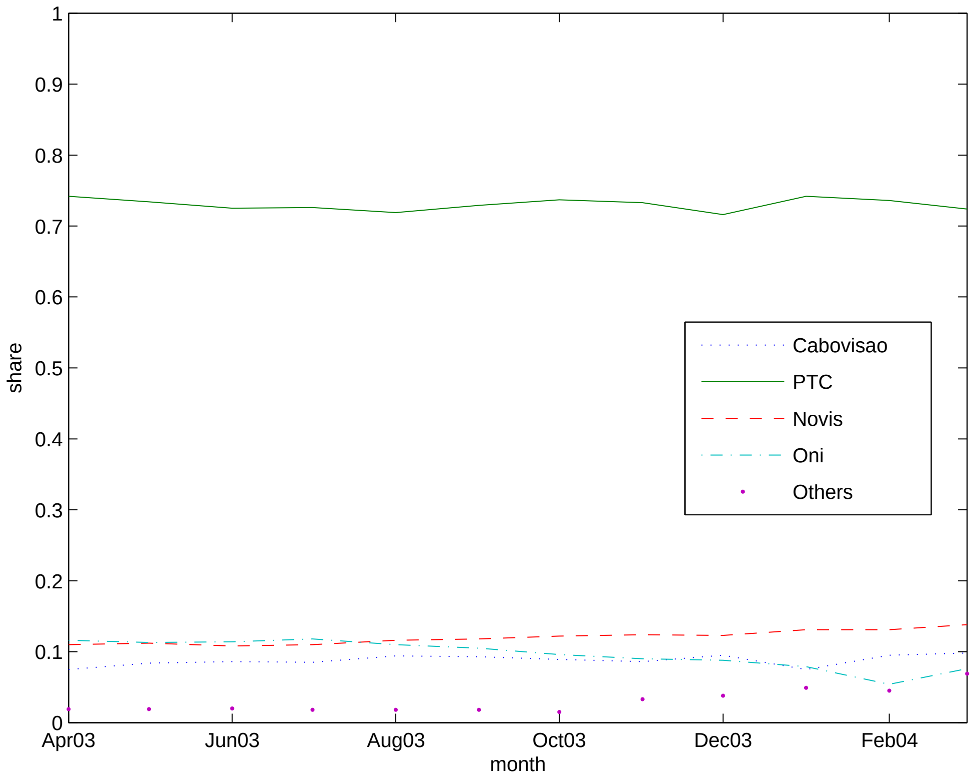

Figure 4: The Total Cost Function for the peak period of the Basic Tariff Plan of *PTC*

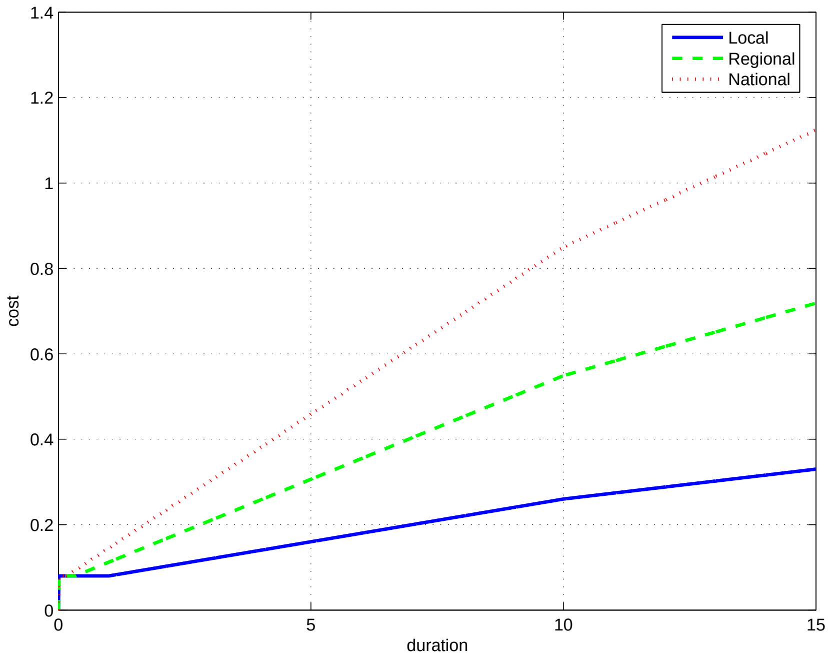

Figure 5: Estimated expected value of a Local and National call with regular tariffs: Histograms

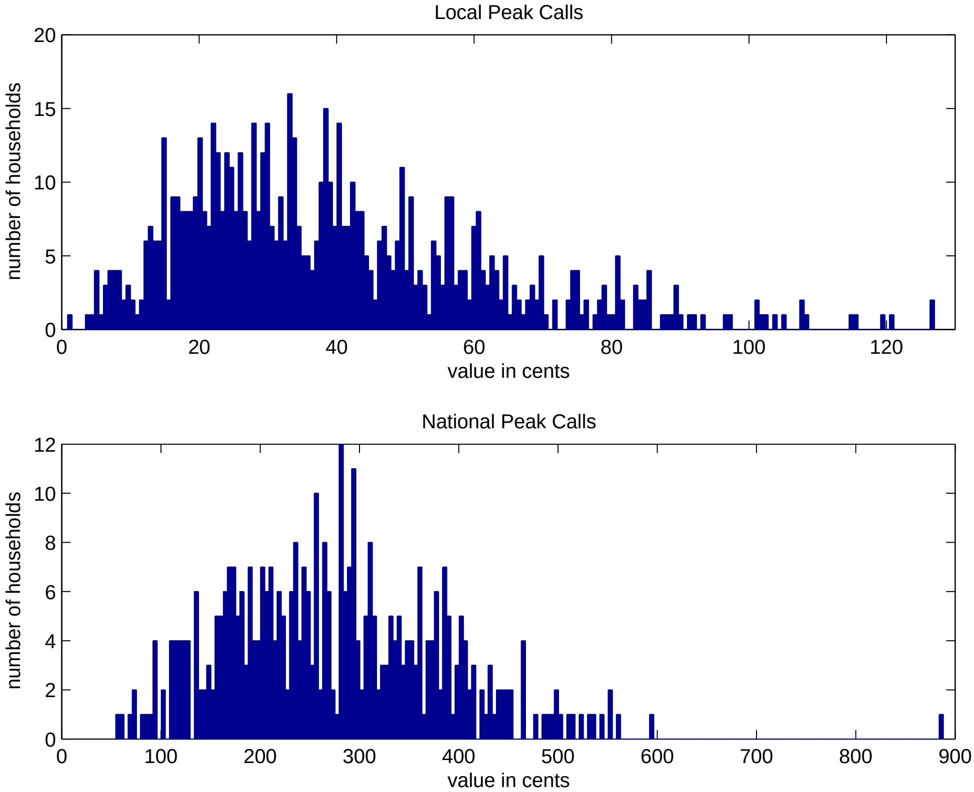

Figure 6: Estimated expected gain for a local call using the alternative Tele 2 tariff: Histogram

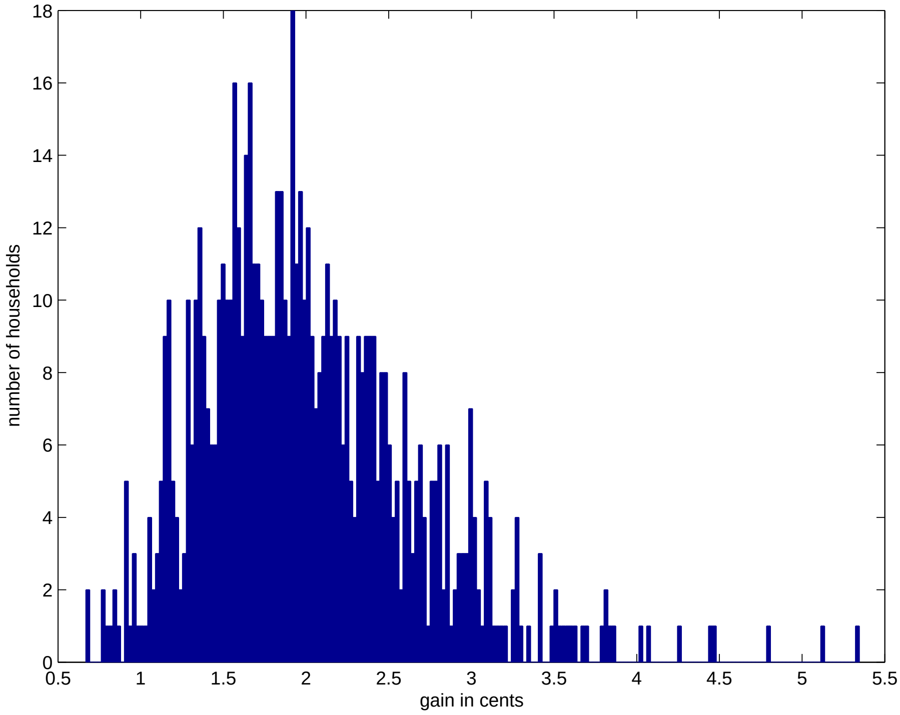

Figure 7: Estimated expected gain for a national call using the alternative Tele 2 tariff: Histogram

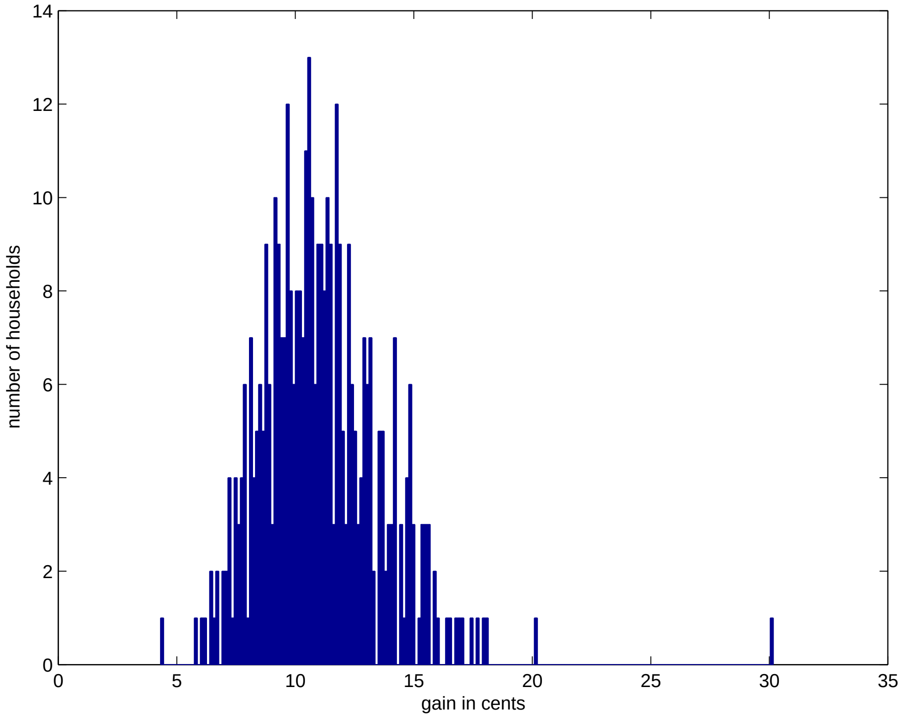

Figure 8: Estimated expected difference in expected number of local peak calls between alternative and regular tariff: Histogram

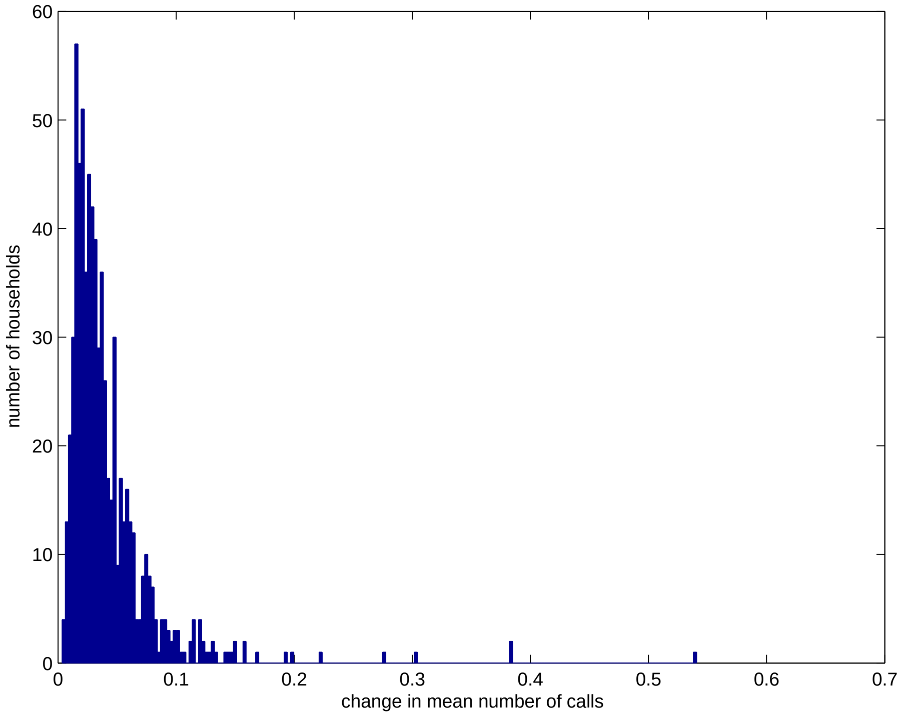

Figure 9: Estimated expected welfare gain: Histogram