Subscription Choices and Switching Costs in Mobile Telephony

Lukasz Grzybowski · Pedro Pereira

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Abstract In this article, we estimate the price elasticities of demand for subscription and consumer switching costs for mobile telephony. We use a panel data of Portuguese consumers to estimate a series of multinomial and mixed logit models. The demand for subscription is found to be elastic and switching costs are large. We use the structural model to perform several policy exercises. Switching costs and brand preferences are shown to be important elements of the market structure of mobile telephony. Price mediated network effects seem to be relatively less important.

Keywords Mobile telephony · Switching costs · Mixed logit

JEL Classification L13 · L43 · L93

1 Introduction

Switching costs limit the ability of consumers to change a supplier and take advantage of price differences.\(^1\) This reduces the substitutability of products, and as a consequence firms may be able to sustain higher prices. Sometimes switching costs are

\(^1\) Switching cost is a one-time product-specific cost, pecuniary or not, that a consumer must bear to change a supplier, in a context of repeat purchase. See Farrell and Klemperer (2007) for a review of the literature on switching costs and network effects.

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inherent to the products in question: e.g., learning how to use a new computer operating system. Other times switching costs are created by firms, and can be reduced by policy measures: e.g., contract termination costs. Hence, the estimation of switching costs has been at the center of many antitrust cases and regulatory proceedings.

Mobile telephony is frequently cited as an example of an industry in which switching costs play an important role. Changing of supplier involves various pecuniary and non-pecuniary costs. Consumers incur search costs to choose their new provider and tariff plan. Moreover, they incur transaction costs to terminate the contract with the old provider and to get a contract with the new one. If consumers change their telephone number, they have to inform their friends and associates of the new number. Number portability mitigates this problem but it may not be a hassle-free process. In addition, consumers face uncertainty about the quality of service of the new provider. The relative importance of these costs varies according to whether consumers have pre-paid or post-paid tariffs. Amante and Vareda (2010), based on a survey conducted in Portugal in 2009, report consumers consider that the biggest obstacles to a switch of supplier are: (i) informing friends and associates of a new telephone number, and (ii) the concern with losing quality of service.

In this article, we use multinominal logit and mixed logit models to estimate the price elasticities of demand for subscription and consumer switching costs for mobile telephony. Our data set consists of a rich panel of monthly invoices of a representative group of 800 Portuguese consumers of mobile telephony services between April 2003 and March 2004. We use our structural model to perform several policy exercises that illustrate the importance of switching costs for the market structure of mobile telephony, and evaluate their impact on the consumer welfare.

Switching costs cause dependency between consumption choices over time. Following Heckman (1981) true and spurious state dependency can be distinguished. True state dependency is a consequence of all observable factors, including switching costs. Spurious state dependency results from persistent heterogeneity in the preferences for brands. Consumers may continue buying the same product because it better fits their individual tastes. We account for spurious state dependence by estimating mixed logit models for panel data. If spurious state dependence is ignored, the parameters that represent switching costs may be biased.4

The estimation results indicate that there is persistence in consumers’ choices of network operators. However, switching costs play a more important role in explaining customer choices and market structure. The demand for subscription is found to be elastic with respect to price, but the price elasticities vary substantially across network operators and their consumers. The own-price elasticities of demand of Tmn, Vodaf-

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2 For detailed discussion of switching costs in the mobile telecommunications industry see the report by NERA (2003).

3 In Portugal there is number portability but relatively few numbers have been ported.

4 There is a large body of empirical studies that try to separate true and spurious state dependency. Among studies specifically on switching costs Chen and Forman (2003), suggest two strategies to separate switching costs from spurious state dependency. They employ an instrumental variable approach and mixed logit estimation and they find high switching costs in the market for routers and switches. Goldfarb (2006) measures loyalty for Internet portals controlling for household-specific heterogeneity by estimating a separate regression for each household. Shum (2004) accommodates unobserved heterogeneity via random effects.
one, and Optimus have, respectively, a mean of: −1.65, −2.10, and −2.33. These high values suggest that consumers perceive the services that are offered by different network operators as close substitutes. Switching costs, which are found to be large, decrease product substitutability.

The policy exercises show that, if switching costs were reduced to zero, the annual consumer surplus would increase by as much as 44.7%. Switching costs and brand preferences are shown to be important characteristics of mobile telephony. Price-mediated network effects seem to be relatively less important in determining market structure. This analysis provides a guideline for policy makers on the extent to which reductions in switching costs increase consumer surplus.

The remainder of the article is organized as follows. Section 2 discusses relevant literature. Section 3 presents briefly industry background. Section 4 introduces the econometric framework. Section 5 presents and discusses the estimation results. Section 6 conducts the policy exercises and the final Sect. 7 concludes.

2 Literature Review

There is a shortage of detailed data on purchase history of individual consumers in the telecommunications industry, because of which few studies estimate both price elasticities and switching costs in telecommunications markets.

Among the studies estimating price elasticities of demand in telecommunications industry Ben-Akiva et al. (1987), use data from US households and a nested logit model to analyze the choices of local telephone tariff plans. They estimate the price elasticities of demand for each local service option, the number of calls, average duration, revenues with respect to the fixed monthly charges and the usage charges for calling under each option. In another study Kridel et al. (2002), analyze how customers select carriers for long distance for the intraLATA market using detailed call information from invoices of residential consumers. Heitfield and Levy (2001) use billing information and demographic data to analyze the joint distribution of the number and the duration of calls. They estimate a hazard model for the duration of calls and find that the demand for duration is inelastic with respect to price. Rodini et al. (2003) estimate the substitutability of fixed and mobile services for telecommunications access, using data for US households.

Among the few studies that estimate switching costs in the telecommunications industry Knittel (1997), analyzes the changes in prices for long distance telephone calls in the US after the divestiture of AT&T in 1984, and explains price rigidity through search and switching costs. Epling (2002) studies competition in the long distance telephony market in the US after 1996. She finds evidence of heterogeneity in subscriber switching costs, and she finds that consumers with high switching costs pay higher prices. Viard (2005) analyzes the impact of the introduction of number

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5 The difference between the cost of on-net and off-net calls may lead consumers to prefer to subscribe to a network operator with a large number of clients instead of a network operator with a small number of clients. This effect is referred to as price mediated network effects. Note that these are not network effects since a consumer’s utility does not increase directly with the number of other consumers that join the same network operator.
portability on prices for toll-free numbers in the US. He finds that when firms cannot discriminate between old locked-in consumers and new ones switching costs may have an ambiguous effect on prices. Lee et al. (2006) estimate the effect of number portability on switching costs in the Korean mobile telecommunications industry. Kim (2006) uses aggregate data on Korean mobile telephony to estimate a dynamic structural model of switching decisions between tariff plans and firms. She finds that the magnitude of switching costs varies across networks and that a change in the variety of optional plans and plan characteristics plays a role in the consumer switching decision. Finally, Grzybowski (2007) uses a mixed logit model to estimate firm-specific switching costs in mobile telephony in the UK but limited data do not allow estimating price elasticities. He finds that both switching costs and persistent tastes lead to state-dependent choices.

Our article contributes to the empirical literature on switching costs by using a detailed consumer-level panel data for mobile telephony in Portugal and mixed logit models to estimate: (i) price elasticities, (ii) switching costs, and (iii) unobserved heterogeneity. We use the panel structure of the data to estimate the dependency of current network operator choices on the past subscription. The structural demand estimates allow us to analyze the impact of prices, switching costs, and unobserved brand preferences on the market structure. Our findings show that there is persistence in consumers’ preferences for network operators, but the role of switching costs is more important for explaining customer choices and market structure.

3 Industry Background

The Portuguese mobile telephony industry consists of three firms: Tmn, Vodafone, and Optimus, which in 2005 had revenue market shares of 50, 37, and 13%, respectively. The asymmetry in market shares is largely due to differences in the time of entry, as shown in Figure 1.

In 1989, the telecommunications incumbent, Tmn, was assigned a license to operate an analogue network. In 1992, Tmn and the entrant Vodafone were assigned licences to operate digital networks on the GSM 900 frequency band. In 1997, these two firms and the entrant, Optimus, were assigned licenses to operate on the GSM 1800 frequency band. Optimus was also assigned a license to operate on the GSM 900 frequency band. Finally, in 2001 these three firms were assigned licenses to operate the UMTS technology. A fourth license was assigned to entrant, Oniway, which never operated.

4 Econometric Model

This section presents the econometric model.

4.1 Utility of Mobile Telephony Subscription

We use a standard linear utility specification, in which the choice of network operator in period $t$ depends on: (i) the expected cost of using mobile services in
Fig. 1 Growth of mobile telephony in Portugal

period \( t \); (ii) whether consumers subscribed to the same or another network operator in period \( t - 1 \); (iii) unobservable consumer preferences; and (iv) observable consumer characteristics.\(^6\) In particular, consumers in different age groups, living in different regions, and belonging to different social classes may differ in their preferences for network operators. As discussed in the introduction, we account for the unobservable consumer preferences by estimating mixed logit models for panel data. If spurious state dependency is ignored, the parameters that represent switching costs may be biased.

Before subscribing to a network operator, consumers form expectations about their usage of mobile phones.\(^7\) We assume that a consumer’s expected calling pattern is inde-

\(^6\) The other potential choice determinants, such as the coverage, reception and service quality, are assumed to be constant throughout the time period of this study.

\(^7\) Actually, consumers make three interrelated decisions. First, they choose a network operator. Second, they choose the number of calls made and the number of messages sent. Third, they choose the duration of the calls. Because there is no information on tariffs, we cannot link the demands for calls and messages and the choice of network operators. However, even with information on tariffs, modeling demand in this way would be complicated due to the range of different services available and prices varying by time and destination of calls.
pendent of the network operator to which he subscribes. This assumption is justifiable because the demand for usage appears to be inelastic, as found in earlier studies.\(^8\)

We index consumers with subscript \(i = 1, \ldots, N\), firms with subscript \(j = 1, \ldots, J\), and time with subscript \(t = 1, \ldots, T\). Each firm offers one product.

Denote by \(p_{ijt}\), the price for individual \(i\) of alternative \(j\) in period \(t\) and denote by \(z_{it}\), a vector of characteristics of consumer \(i\) in period \(t\), with generic element \(z_{ikt}\). The consumer characteristics are: (i) age; (ii) gender; (iii) residence in the Lisbon region; and (iv) social class. As shown in Table 1 there are differences in the distribution of these characteristics across operators.

Denote by \(s_{ijt}\), a dummy variable that takes the value 0 if consumer \(i\) chooses in period \(t\) the same alternative \(j\) he chose in period \(t - 1\) and value 1 otherwise. This variable accounts for switching costs and its coefficient is interpreted as the disutility of changing the network operator. Note that the variable that represents switching costs, \(s_{ijt}\), differs, by construction, from brand preferences. This definition of switching costs variable can be also found in previously cited studies by Lee et al. (2006), Kim (2006), and Grzybowski (2007).

After forming expectations about the cost of using mobile telephony services, a consumer chooses the firm to which he subscribes. Consumer \(i\) derives from alternative \(j\) in period \(t\) utility given by:

\[
U_{ijt}(p_{ijt}, z_{it}, s_{ijt}, \xi_{ij}; \theta) = V_{ijt}(p_{ijt}, z_{it}, s_{ijt}, \xi_{ij}; \theta) + \epsilon_{ijt},
\]

where \(\epsilon_{ijt}\) is a stochastic error term, which is identically and independently distributed across individuals, alternatives, and periods, and follows a Type I extreme value distri-

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\(^8\) Grzybowski and Pereira (2008) estimate a price elasticity of demand for mobile telephone calls of \(-0.38\), and Grzybowski and Pereira (2009) find a price elasticity of demand for the duration of mobile telephone calls of \(-0.2\).
bution with a scale parameter $\sigma_\epsilon$. The vector of parameters of variables $(p_{ijt}, z_{it}, s_{ijt})$ to be estimated is denoted by $\theta$.

Let $\xi = (\xi_{i1}, \xi_{i2})$ denote the unobservable individual heterogeneity component. It is identically and independently distributed across individuals, and follows a joint-normal distribution with density function denoted by $\xi_{ij} \sim f(\xi|\mu, \Sigma)$, where $\mu$ is the mean of $\xi_{ij}$ and $\Sigma$ is the variance-covariance matrix. In addition, the unobservable individual heterogeneity component, $\xi_{ij}$, and the error term, $\epsilon_{ijt}$, are assumed to be uncorrelated with the explanatory variables, $(p_{ijt}, z_{it}, s_{ijt})$.

We assume additionally that:

$$V_{ijt}(p_{ijt}, z_{it}, s_{ijt}, \xi_{ij}; \theta) = -\alpha p_{ijt} + \sum_k \beta_{jk} z_{ikt} + \gamma s_{ijt} + \xi_{ij},$$

where $\alpha$ is the price coefficient (i.e., the negative of the marginal utility of income), $\beta$ is the vector of the coefficients of consumer characteristics with generic element $\beta_{jk}$, and $\gamma$ is the coefficient of switching costs dummy variable $s_{ijt}$. The estimate of $\gamma$ is fundamental in this article.

4.2 Choice Probabilities

Denote by $\mathbf{p}_{it}$, the vector of prices that consumer $i$ faces in period $t$. The assumptions on $\epsilon_{ijt}$ imply that conditional on the individual specific variable, $\xi$, the choice probability of each firm is given by the logit formula. Thus, the conditional probability of consumer $i$ selecting alternative $j$ in period $t$ is:

$$P_{ijt}(\xi) = \Pr[j|\mathbf{p}_{it}, \cdot, \xi] = \frac{\exp(V_{ijt}(\xi_{ij}))}{\sum_{k \in J} \exp(V_{ikt}(\xi_{ik}))}.$$

The unconditional choice probability is:

$$\tilde{P}_{ijt} = \int_{\xi} P_{ijt}(\xi) f(\xi|\mu, \Sigma) d\xi. \quad (1)$$

This specification can be generalized to the case of repeated choices. On the assumption that the coefficients are constant over time, the unconditional probability (1) for a sequence of choices is:

$$\tilde{P}_{ijt} = \int_{\xi} \prod_t P_{ijt}(\xi) f(\xi|\mu, \Sigma) d\xi. \quad (2)$$

9 The utility of Vodafone is normalized to zero and all the estimates are interpreted relative to Vodafone.

10 The utility specification that is commonly used in the literature includes an additive income term, which can be subtracted from all the alternatives because only relative utility matters. Hence, the price coefficient can be interpreted in terms of marginal utility of income.

11 Since many individuals did not provide bills for the whole period of time the panel is unbalanced.
4.3 Demand Elasticities

Denote by $\varepsilon_{i j k t}$, the elasticity of demand of product $j$ with respect to the price of product $k$ for consumer $i$ in period $t$:

$$\varepsilon_{i j k t} := \frac{\partial P_{ijt}}{\partial p_{ikt}} \frac{p_{ikt}}{P_{ijt}}.$$ 

In the multinomial logit model, the partial derivative is:

$$\frac{\partial P_{ijt}}{\partial p_{ikt}} = \begin{cases} -\alpha P_{ijt} (1 - P_{ijt}) & \text{if } k = j \\ \alpha P_{ijt} P_{ikt} & \text{otherwise}; \end{cases}$$

which implies the following elasticities:

$$\varepsilon_{i j k t} = \begin{cases} -\alpha p_{ijt} (1 - P_{ijt}) & \text{if } k = j \\ \alpha p_{ikt} P_{ikt} & \text{otherwise}. \end{cases}$$

In the mixed logit model, the partial derivative of the choice probabilities is:

$$\frac{\partial \tilde{P}_{ijt}}{\partial p_{ikt}} = \begin{cases} -\alpha \int \xi \frac{P_{ijt}(\xi)(1 - P_{ijt}(\xi)) f(\xi | \mu, \Sigma)}{\sum_{k \in J} \exp(V_{ikt}(\xi_{ik}))} d\xi & \text{if } k = j \\ \alpha \int \xi \frac{P_{ijt}(\xi) P_{ikt}(\xi) f(\xi | \mu, \Sigma)}{\sum_{k \in J} \exp(V_{ikt}(\xi_{ik}))} d\xi & \text{otherwise}, \end{cases}$$

where $P_{ijt}(\xi) = \frac{\exp(V_{ijt}(\xi_{ij}))}{\sum_{k \in J} \exp(V_{ikt}(\xi_{ik}))}$, and the elasticities are obtained analogously.

4.4 Consumer Surplus

Denote by $V^0_{ijt}(\xi)$ and $V^1_{ijt}(\xi)$, the utility levels before and after a price increase, respectively. The change in consumer surplus caused by a price increase can be represented by a compensating variation. It captures the amount of money by which consumers would need to be compensated to maintain the same level of utility after a change in price (Small and Rosen 1981). This formula for consumer $i$ is given by:

$$CV_i = \frac{1}{\alpha} \sum_i \int \xi \left[ \ln \left( \sum_{j \in J} \exp(V^1_{ijt}(\xi_{ij})) \right) 
- \ln \left( \sum_{j \in J} \exp(V^0_{ijt}(\xi_{ij})) \right) \right] f(\xi | \mu, \Sigma) d\xi.$$  \hspace{1cm} (3)

4.5 Estimation Strategy

The identification of state dependency is based on the comparison of the choices of consumers who subscribed to a given network operator in the previous period with the
choices of the consumers who subscribed to the other operators, and the comparison of the price levels that were offered. The churn rate in the data is 4% a year. Since comparatively few consumers switch firms, we assume that switching costs are the same across network operators.\(^{12}\) The much greater share of consumers who choose the same network operator rather than the other ones is reflected in the negative estimate of the switching costs dummy variable, which is interpreted as the disutility of changing network operators.

Based on the computed costs of using alternative network operators, 62% of consumers subscribe to the cheapest firm.\(^{13}\) The remaining consumers use more expensive providers due to: (i) switching costs, (ii) persistent brand preferences, or (iii) information asymmetry about the cost of the alternatives. They do not switch even though they could reduce their expenses for mobile telephony services.

A common concern in the estimation of switching costs with dynamic discrete choice models is the difficulty of distinguishing true state dependency from spurious state dependency. In the simple logit model we ignore spurious state dependency and estimate mean population tastes represented by \(\mu_j\). In the mixed logit model we estimate both the means, \(\mu_j\), and the standard deviations, \(\sigma_{\mu_j}\), which represent the distribution of tastes in the population. Identification is achieved by using the panel structure of the data and assuming that brand effects, represented by the means, \(\mu_j\), are independent from switching costs, represented by the dummy variable, \(s_{ijt}\).

The probabilities in (2) are approximated through simulation. First, we draw a vector of values \(\xi^r\) from joint normal distribution \(N(\mu, \Sigma)\), and label it with subscript \(r = 1\). Second, given the value of \(\xi^r\), we calculate the logit formula inside the integral in (2). We repeat these two steps \(R\) times and calculate the simulated choice probability through the average:

\[
\hat{P}_{ijt} = \frac{1}{R} \sum_{r=1}^{R} \left[ \prod_t \frac{\exp(V_{ijt}(\xi^r_{ij}))}{\sum_{k \in J} \exp(V_{ikt}(\xi^r_{ik}))} \right].
\]

The simulated log-likelihood function for a given sequence of choices is given by:

\[
\mathcal{L}(\alpha, \beta, \gamma, \mu, \Sigma) = \sum_i \log(\hat{P}_{ijt}).
\]

The maximum simulated likelihood estimator is the value the coefficients of the utility function \((\alpha, \beta, \gamma)\) and of the distribution parameters, \(N(\mu, \Sigma)\) that maximizes \(\mathcal{L}\).\(^{14}\)

To implement the random-effects approach, we assume that: (i) the initial choices are exogenous, and (ii) the joint distribution of the unobserved effects does not depend

\(^{12}\) It is possible to estimate firm-specific switching costs in a multinomial logit model. These estimates, however, do not vary significantly across firms and the likelihood ratio test cannot reject the null hypothesis of their equality. In the mixed logit model, firm-specific switching costs cause problems in the identification of random effects.

\(^{13}\) For each individual, based on the usage pattern on the invoice, the cost of subscribing to alternative network operators is computed and compared to the invoice value.

\(^{14}\) The algorithm for estimating a mixed logit model is explained in detail in Train (2003).
on the initial choices. These assumptions ensure that the distribution of the unobserved heterogeneity parameters is invariant to the initial choices. The assumption that the initial conditions are exogenous can bias the estimates of state dependency upwards and bias the estimates of heterogeneity downwards.\(^{15}\)

5 Econometric Implementation

In this section, we: (i) describe the data, (ii) present the estimation results, and (iii) present the price elasticities of demand.

5.1 Data

The data used in this study consist of a micro panel of 800 individuals, based on monthly scanned invoices with detailed information about all of the calls, messages, and other types of communications made by individuals. The information was collected for mainland Portugal, between April 2003 and March 2004. The sample is representative of the whole population segmented by age, five social classes and six regions.\(^{16}\) The data set was produced by Marktest, a Portuguese marketing research firm that collects and sells data on consumer behavior for various industries. The Portuguese Competition Authority acquired the data set and allowed us to use it for this study. This data set has never been used for academic research purposes before. Table 1 shows statistics of the sample.

Table 2 shows the information recorded for every single communication made by an individual. Calls to mobile networks, calls to fixed networks, and messages account for 95% of all the communications within the whole sample of consumers. These prices are used to compute the value of the bill paid by individuals each month. Table 3 shows the average monthly invoice values in the sample. Table 4 presents subscriber market shares in the sample in each month.

For the consumers’ choices of which firm to subscribe to, we need to assign to each individual: (i) the cost of using the service to which he subscribes, and (ii) the cost of using the alternatives. There is, unfortunately, no information in the data about the tariff plans chosen by the individuals, which would make it easier to compute the cost

\(^{15}\) It is not possible to estimate the model for the first period because the first period choices depend on choices in the earlier periods, which are not observed. Moreover, the initial choices depend on unobserved heterogeneity and are therefore endogenous. Since we ignore this initial dependence, in the estimation, a greater value is put on switching costs and a lower value on the unobserved heterogeneity. The short time period between the first and the last observations in our data set and the resulting small number of switching consumers make it difficult to account for endogenous initial conditions. Solutions to the problem of endogenous initial conditions for the dynamic probit model are discussed in Heckman (1981) and Wooldridge (2005). Heckman (1981) proposes approximating the conditional distribution of the initial condition. Wooldridge (2005) suggests modeling the distribution of the unobserved effect conditional on the initial value and exogenous explanatory variables.

\(^{16}\) The stratification of the sample was based on the 2001 census data from the Portuguese National Statistics Institute. The social class levels are: 1—High, 2—Medium/High, 3—Medium, 4—Medium/Low, 5—Low. The regions are: 1—Greater Lisbon, 2—Greater OPorto, 3—Northern Coast, 4—Central Coast, 5—Northern Interior, 6—South.
Table 2  Information recorded about calls

<table>
<thead>
<tr>
<th>Originating network</th>
<th>Optimus, Tmn, Vodafone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of call</td>
<td>International services, n800, messages</td>
</tr>
<tr>
<td>Value of call</td>
<td>Cents without VAT</td>
</tr>
<tr>
<td>Date of call</td>
<td>Year/month/day</td>
</tr>
<tr>
<td>Time of call</td>
<td>Hour/minute/second</td>
</tr>
<tr>
<td>Length of call</td>
<td>Year/month/day</td>
</tr>
</tbody>
</table>

Table 3  Monthly average bill values (Euros)

<table>
<thead>
<tr>
<th>Month</th>
<th>Optimus No.</th>
<th>Bill</th>
<th>Tmn No.</th>
<th>Bill</th>
<th>Vodafone No.</th>
<th>Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>04.2003</td>
<td>181</td>
<td>13.82</td>
<td>422</td>
<td>13.66</td>
<td>259</td>
<td>16.21</td>
</tr>
<tr>
<td>05.2003</td>
<td>191</td>
<td>14.97</td>
<td>442</td>
<td>14.02</td>
<td>263</td>
<td>17.83</td>
</tr>
<tr>
<td>06.2003</td>
<td>189</td>
<td>15.12</td>
<td>439</td>
<td>12.96</td>
<td>267</td>
<td>19.45</td>
</tr>
<tr>
<td>07.2003</td>
<td>199</td>
<td>15.93</td>
<td>421</td>
<td>15.51</td>
<td>269</td>
<td>22.35</td>
</tr>
<tr>
<td>08.2003</td>
<td>192</td>
<td>16.73</td>
<td>444</td>
<td>13.65</td>
<td>284</td>
<td>21.07</td>
</tr>
<tr>
<td>09.2003</td>
<td>201</td>
<td>15.94</td>
<td>450</td>
<td>14.11</td>
<td>289</td>
<td>21.49</td>
</tr>
<tr>
<td>10.2003</td>
<td>190</td>
<td>12.87</td>
<td>457</td>
<td>13.12</td>
<td>296</td>
<td>19.43</td>
</tr>
<tr>
<td>11.2003</td>
<td>103</td>
<td>17.86</td>
<td>423</td>
<td>12.89</td>
<td>300</td>
<td>21.21</td>
</tr>
<tr>
<td>12.2003</td>
<td>132</td>
<td>14.24</td>
<td>437</td>
<td>15.03</td>
<td>289</td>
<td>22.89</td>
</tr>
<tr>
<td>01.2004</td>
<td>104</td>
<td>16.76</td>
<td>420</td>
<td>12.91</td>
<td>298</td>
<td>19.25</td>
</tr>
<tr>
<td>02.2004</td>
<td>113</td>
<td>15.06</td>
<td>428</td>
<td>12.78</td>
<td>292</td>
<td>17.56</td>
</tr>
<tr>
<td>03.2004</td>
<td>143</td>
<td>14.84</td>
<td>454</td>
<td>13.71</td>
<td>307</td>
<td>17.67</td>
</tr>
</tbody>
</table>

Table 4  Subscriber market shares

<table>
<thead>
<tr>
<th>Month</th>
<th>No.</th>
<th>Optimus (%)</th>
<th>Tmn (%)</th>
<th>Vodafone (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>04.2003</td>
<td>862</td>
<td>21</td>
<td>49</td>
<td>30</td>
</tr>
<tr>
<td>05.2003</td>
<td>896</td>
<td>21</td>
<td>49</td>
<td>30</td>
</tr>
<tr>
<td>06.2003</td>
<td>895</td>
<td>21</td>
<td>49</td>
<td>30</td>
</tr>
<tr>
<td>07.2003</td>
<td>889</td>
<td>22</td>
<td>47</td>
<td>30</td>
</tr>
<tr>
<td>08.2003</td>
<td>920</td>
<td>21</td>
<td>48</td>
<td>31</td>
</tr>
<tr>
<td>09.2003</td>
<td>940</td>
<td>21</td>
<td>48</td>
<td>31</td>
</tr>
<tr>
<td>10.2003</td>
<td>943</td>
<td>20</td>
<td>48</td>
<td>31</td>
</tr>
<tr>
<td>11.2003</td>
<td>826</td>
<td>12</td>
<td>51</td>
<td>36</td>
</tr>
<tr>
<td>12.2003</td>
<td>858</td>
<td>15</td>
<td>51</td>
<td>33</td>
</tr>
<tr>
<td>01.2004</td>
<td>822</td>
<td>13</td>
<td>51</td>
<td>37</td>
</tr>
<tr>
<td>02.2004</td>
<td>833</td>
<td>14</td>
<td>51</td>
<td>35</td>
</tr>
<tr>
<td>03.2004</td>
<td>904</td>
<td>16</td>
<td>50</td>
<td>34</td>
</tr>
</tbody>
</table>
of using alternatives. We have to infer these costs based on prices that were paid by consumers for calls and messages recorded on their invoices.\textsuperscript{17}

We compute the cost of using mobile services as follows: first, for all subscribers to a given network operator in a given month, we calculate the average per-second price of calling mobile and fixed line numbers at certain times of the day, and days of the week (i.e., weekday or weekend), and similarly for sending messages. We compute the average for all the calls made by individuals in the sample in a given month, which fall into a given category. Table 5 presents the values of average prices for 60-second calls and for messages at different times of the day, and different days of the week in April 2003. There is substantial variation in prices across operators.

The average prices shown in Table 5 are used to calculate, for each customer, the cost of using the services of different firms. We compute the cost not only for the oper-

\begin{table}[h]
\centering
\caption{Average prices of 1-minute calls and messages in April 2003 (Euros)}
\begin{tabular}{lcccc}
\hline
Weekday & Type & Optimus & Tmn & Vodafone \\
\hline
0:00–7:00 & SMS & 0.097 & 0.064 & 0.047 \\
& Fixed & 0.210 & 0.204 & 0.240 \\
& Mobile off-net & 0.213 & 0.407 & 0.222 \\
& Mobile on-net & 0.190 & 0.150 & 0.218 \\
7:00–17:00 & SMS & 0.097 & 0.067 & 0.053 \\
& Fixed & 0.218 & 0.233 & 0.251 \\
& Mobile off-net & 0.228 & 0.313 & 0.255 \\
& Mobile on-net & 0.190 & 0.149 & 0.211 \\
17:00–24:00 & SMS & 0.098 & 0.069 & 0.056 \\
& Fixed & 0.214 & 0.243 & 0.233 \\
& Mobile off-net & 0.226 & 0.303 & 0.245 \\
& Mobile on-net & 0.190 & 0.151 & 0.215 \\
\hline
Weekend & Type & Optimus & Tmn & Vodafone \\
\hline
0:00–7:00 & SMS & 0.098 & 0.063 & 0.058 \\
& Fixed & 0.210 & 0.258 & 0.246 \\
& Mobile off-net & 0.210 & 0.240 & 0.234 \\
& Mobile on-net & 0.199 & 0.151 & 0.238 \\
7:00–17:00 & SMS & 0.098 & 0.070 & 0.055 \\
& Fixed & 0.206 & 0.217 & 0.218 \\
& Mobile off-net & 0.205 & 0.273 & 0.221 \\
& Mobile on-net & 0.197 & 0.145 & 0.220 \\
17:00–24:00 & SMS & 0.098 & 0.072 & 0.057 \\
& Fixed & 0.205 & 0.203 & 0.204 \\
& Mobile off-net & 0.209 & 0.269 & 0.224 \\
& Mobile on-net & 0.189 & 0.147 & 0.224 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{17} The data set does not indicate how much individuals pay for monthly subscription fees. However, in Portugal over 80\% of the subscribers have pre-paid cards. Since our sample is composed of residential clients, the percentage of subscribers with pre-paid cards is certainly greater than this.
Table 6  Average computed cost of alternatives in April 2003 in Euros

<table>
<thead>
<tr>
<th>Consumers of Optimus</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Optimus</td>
<td>13.66</td>
<td>14.24</td>
<td>0.20</td>
<td>84.00</td>
</tr>
<tr>
<td>Computed Optimus</td>
<td>13.57</td>
<td>14.18</td>
<td>0.19</td>
<td>82.33</td>
</tr>
<tr>
<td>Computed Tmn</td>
<td>16.80</td>
<td>18.08</td>
<td>0.13</td>
<td>96.29</td>
</tr>
<tr>
<td>Computed Vodafone</td>
<td>14.44</td>
<td>14.80</td>
<td>0.10</td>
<td>80.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consumers of Tmn</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Tmn</td>
<td>13.81</td>
<td>12.91</td>
<td>0.16</td>
<td>97.42</td>
</tr>
<tr>
<td>Computed Optimus</td>
<td>18.89</td>
<td>19.14</td>
<td>0.41</td>
<td>127.02</td>
</tr>
<tr>
<td>Computed Tmn</td>
<td>15.06</td>
<td>14.63</td>
<td>0.30</td>
<td>110.58</td>
</tr>
<tr>
<td>Computed Vodafone</td>
<td>19.54</td>
<td>20.45</td>
<td>0.43</td>
<td>135.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consumers of Vodafone</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Vodafone</td>
<td>16.61</td>
<td>23.55</td>
<td>0.23</td>
<td>237.48</td>
</tr>
<tr>
<td>Computed Optimus</td>
<td>18.12</td>
<td>25.36</td>
<td>0.22</td>
<td>223.51</td>
</tr>
<tr>
<td>Computed Tmn</td>
<td>20.66</td>
<td>30.66</td>
<td>0.21</td>
<td>277.84</td>
</tr>
<tr>
<td>Computed Vodafone</td>
<td>17.38</td>
<td>24.45</td>
<td>0.21</td>
<td>220.95</td>
</tr>
</tbody>
</table>

ator to which consumers subscribe but also for the other operators. This calculation assumes that consumers would use the alternative network operators in exactly the same way. Moreover, all consumers pay the same average per-second prices, which is a common assumption in most empirical studies. In fact, we are more precise in this article by calculating the variation in price over time and destination.

The differences in usage intensity, timing of messages and in the type, length, and timing of the calls result in differences in the value of the invoices paid by individuals as explained below. These differences allow the identification of own- and cross-price elasticities as well as switching costs, since many consumers do not switch to cheaper alternative.

For the operators to which consumers subscribe, we compute the correlation between the observed and the computed values of the invoices, which are in the range 0.9 or higher, depending on the month and the firm, as shown in Tables 6 and 7. Moreover, 62% of consumers subscribe to the cheapest firm for their observed usage pattern; i.e., the invoice computed in the way described above is the lowest for the firm to which consumers subscribed. This suggests that our procedure is reasonable.

We do not observe individuals who choose not to use mobile services, or who use fixed-line services exclusively. We assume that in the period of this study, all consumers have access to mobile services, which is a justifiable assumption because the penetration rate of mobile telephony in Portugal reached 90% in the second quarter of 2004, and 110% in the fourth quarter of 2005.18

18 The European Commission and national competition authorities in a number of decisions on mobile communications services used product market definition that excluded fixed communications services. The Commission stated that mobile communications services cannot be seen as being substitutable to fixed communications services because of the mobility inherent in all mobile services, i.e., mobile numbers are associated with individuals on the move, rather than with a fixed location.
In principle, the consumers’ income level could influence the consumers’ decision of whether to have a mobile telephone or to which operator to subscribe to. Our data set does not include any direct information about income. However, given the penetration rate of 110% in 2005, it is unlikely that income played a role in the decision of whether to have a mobile telephone. Furthermore, Table 1 illustrates that there are some differences in the type of consumers using different network operators. In particular, Vodafone seems to be chosen more often by individuals from higher social classes.

We model switching costs through the dependence of the subscription choices in the current period on the subscription choices in the previous period. Thus, assuming that consumers choose which firm to subscribe to every month, we lose the observations from the first month. 19

In the estimation we use 8,015 observations. The market shares for the sample used in estimation represent 50.3, 33.5, and 16.2%, for Tmn, Vodafone, and Optimus, respectively, which is similar to observed market shares.

5.2 Estimation Results

We estimate four models by maximum likelihood. 20 The results are presented in Table 8.

---

19 One month decision interval is reasonable because about 80% of subscribers of mobile telephony in Portugal use pre-paid cards. They can buy minutes of conversation for pre-paid cards: (i) using debit cards in ATM machines, (ii) through internet banking, or (iii) from kiosks on the street. Typically, these consumers buy minutes to be used within a week, or within a month at most. Hence, they can get a SIM card from an alternative network operator in any moment.

20 We used the SAS procedure “proc nlmixed” to estimate the mixed logit models.
Table 8  Multinomial logit and mixed logit estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
<th>Model 3</th>
<th></th>
<th>Model 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>t</td>
<td>Estimate</td>
<td>t</td>
<td>Estimate</td>
<td>t</td>
<td>Estimate</td>
<td>t</td>
</tr>
<tr>
<td>Price</td>
<td>-0.478</td>
<td>-42.46</td>
<td>-0.197</td>
<td>-6.70</td>
<td>-0.259</td>
<td>-4.31</td>
<td>-0.216</td>
<td>-5.80</td>
</tr>
<tr>
<td>Opt dummy mean</td>
<td>-0.965</td>
<td>-6.43</td>
<td>-0.786</td>
<td>-0.64</td>
<td>-1.069</td>
<td>-0.05</td>
<td>-0.838</td>
<td>-2.65</td>
</tr>
<tr>
<td>Opt SD</td>
<td></td>
<td></td>
<td>1.814</td>
<td>3.51</td>
<td>1.740</td>
<td>4.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age&lt;30</td>
<td>0.788</td>
<td>7.45</td>
<td>1.064</td>
<td>1.42</td>
<td>1.134</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 30–50</td>
<td>-0.089</td>
<td>-0.99</td>
<td>0.284</td>
<td>0.43</td>
<td>0.245</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lisbon</td>
<td>-0.114</td>
<td>-1.21</td>
<td>0.767</td>
<td>1.07</td>
<td>0.811</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.443</td>
<td>5.79</td>
<td>0.218</td>
<td>0.40</td>
<td>0.204</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-high</td>
<td>-1.888</td>
<td>-8.96</td>
<td>-2.803</td>
<td>-2.01</td>
<td>-3.264</td>
<td>-0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-medium/high</td>
<td>-0.823</td>
<td>-5.39</td>
<td>-0.452</td>
<td>-0.36</td>
<td>-0.085</td>
<td>-0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-medium</td>
<td>-0.857</td>
<td>-5.81</td>
<td>-1.165</td>
<td>-0.96</td>
<td>-1.381</td>
<td>-0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-medium/low</td>
<td>0.003</td>
<td>0.02</td>
<td>0.536</td>
<td>0.42</td>
<td>1.175</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tmn dummy mean</td>
<td>-0.096</td>
<td>-0.67</td>
<td>-0.067</td>
<td>-0.05</td>
<td>-0.324</td>
<td>-0.01</td>
<td>0.124</td>
<td>0.41</td>
</tr>
<tr>
<td>Tmn SD</td>
<td></td>
<td></td>
<td>1.764</td>
<td>4.02</td>
<td>1.586</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age&lt;30</td>
<td>0.364</td>
<td>4.26</td>
<td>0.065</td>
<td>0.09</td>
<td>0.164</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 30–50</td>
<td>0.042</td>
<td>0.58</td>
<td>-0.112</td>
<td>-0.17</td>
<td>-0.037</td>
<td>-0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lisbon</td>
<td>-0.345</td>
<td>-4.66</td>
<td>-0.063</td>
<td>-0.09</td>
<td>0.145</td>
<td>0.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.300</td>
<td>4.92</td>
<td>0.306</td>
<td>0.55</td>
<td>0.334</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-high</td>
<td>0.018</td>
<td>0.11</td>
<td>0.057</td>
<td>0.04</td>
<td>-0.502</td>
<td>-0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-medium/high</td>
<td>0.178</td>
<td>1.23</td>
<td>0.367</td>
<td>0.28</td>
<td>0.586</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-medium</td>
<td>0.167</td>
<td>1.18</td>
<td>-0.157</td>
<td>-0.12</td>
<td>-0.442</td>
<td>-0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class-medium/low</td>
<td>0.381</td>
<td>2.58</td>
<td>0.832</td>
<td>0.61</td>
<td>1.361</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>-5756</td>
<td></td>
<td>-177</td>
<td></td>
<td>-171</td>
<td></td>
<td>-179</td>
<td></td>
</tr>
<tr>
<td>Obs</td>
<td>8015</td>
<td></td>
<td>8015</td>
<td></td>
<td>8015</td>
<td></td>
<td>-8015</td>
<td></td>
</tr>
</tbody>
</table>

Model 1—without switching costs; Model 2—without unobserved heterogeneity; Model 3—with switching costs, unobserved heterogeneity, consumer characteristics; Model 4—without consumer characteristics (used for policy exercises).

Model 1 is a multinomial logit model without switching costs. The estimates of the price coefficient and consumer characteristics are statistically significant.

Model 2 is a multinomial logit model with switching costs. Compared with Model 1, Model 2 has a much larger log-likelihood. Moreover, the estimate of the price coefficient decreases, but remains significant. Consumer characteristics are not statistically significant in determining the choice of Optimus and Tmn compared to Vodafone. As suggested by the estimates of Model 1 and also by the sample statistics in Table 1, consumer characteristics may have a significant impact on network operator choices. We cannot however identify their impact once the switching costs dummy variable is included. Because few consumers switch provider, prices and switching costs explain
almost perfectly the choice probabilities.\textsuperscript{21} The estimate of the coefficient of the switching costs dummy variable is negative, relatively large, and highly statistically significant. This suggests that consumers have substantial switching costs. However, this specification ignores the presence of unobservable persistent heterogeneity which may bias the estimates of switching costs.

Model 3 is a mixed logit model with switching costs and persistent unobserved brand preferences. This specification implies a contemporaneous and an intertemporal dependence of choices. Compared with Model 2, the overall fit improves. The likelihood ratio test rejects the null hypothesis that there is no persistent consumer heterogeneity. The test statistic $\chi^2 = 12$ is larger than the critical value for 2 degrees of freedom $\chi^2(0.01, 2) = 9.21$. Moreover, the estimates of the coefficients of prices and the dummy variable for switching costs increase. The estimates of the coefficients of the means are insignificant for both Optimus and Tmn, but have significant standard deviations. The estimates of the coefficients of the consumer characteristics are insignificant as before. Therefore, the choice probabilities are explained by: (i) prices, (ii) switching costs, and (iii) persistent unobserved brand preferences.

Model 4 is similar to Model 3, except that it excludes consumer characteristics. The estimate of the coefficient of the firm dummy variable is significant and negative for Optimus, and insignificant for Tmn. Thus, on average, consumers value Tmn and Vodafone equally but relatively more than Optimus. However, given the standard deviations, there are consumers with both higher and lower valuations for Optimus relative to Vodafone, and similarly for Tmn. We select Model 4 to conduct our analysis in the next sections.

5.3 Price Elasticities of Demand

Table 9 presents the own- and cross-price elasticities of demand for the whole sample of individuals.

The own- and cross-price elasticities are large and vary substantially across firms and their consumers. The own-price elasticity of the demand of Tmn has a mean of $-1.65$, a median of $-0.05$, and a standard deviation of 2.89. If the price of Tmn increases 1%, on average, the number of subscribers of Tmn decreases 1.65%.

\textsuperscript{21} The coefficients on consumer characteristics are alternative-specific. After the normalization $(\beta_j - \beta_3)$ is estimated, and the coefficients are then interpreted relative to the coefficient of alternative 3.
Table 10  Market shares simulations (based on model 4)

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Optimus (%)</th>
<th>Tmn (%)</th>
<th>Vodafone (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>16</td>
<td>50</td>
<td>34</td>
</tr>
<tr>
<td>$s = 0$ for all</td>
<td>26</td>
<td>42</td>
<td>32</td>
</tr>
<tr>
<td>$s = 0$ for all, Prices on-net = off-net for Tmn</td>
<td>27</td>
<td>40</td>
<td>33</td>
</tr>
<tr>
<td>$s = 0$ for Optimus</td>
<td>45</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>$s = 0$ for Tmn</td>
<td>8</td>
<td>72</td>
<td>20</td>
</tr>
<tr>
<td>$s = 0$ for Vodafone</td>
<td>7</td>
<td>32</td>
<td>61</td>
</tr>
<tr>
<td>$s = 0$ for all, equal prices for Tmn and Vodafone</td>
<td>29</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>Price = 0 for Optimus</td>
<td>25</td>
<td>46</td>
<td>29</td>
</tr>
<tr>
<td>Price = 0 for Tmn</td>
<td>14</td>
<td>58</td>
<td>28</td>
</tr>
<tr>
<td>Price = 0 for Vodafone</td>
<td>14</td>
<td>45</td>
<td>41</td>
</tr>
</tbody>
</table>

The cross-price elasticities of the demand of Tmn with respect to the prices of Vodafone and Optimus are 1.29 and 1.24, respectively. If the price of Vodafone increases 1%, on average, the number of subscribers of Tmn increases 1.29%. The own-price elasticity of the demand of Vodafone has a mean of $-2.10$, a median of $-1.30$, and a standard deviation of 2.64. The cross-price elasticities of the demand of Vodafone with respect to the prices of Tmn and Optimus are both 0.97. Finally, the own-price elasticity of the demand of Optimus has an average of $-2.33$, a median of $-1.70$, and a standard deviation of 2.57. The cross-price elasticities of the demand of Optimus with respect to the prices of Tmn and Vodafone are 0.43 and 0.49, respectively.\footnote{Grzybowski and Pereira (2007) also find that the demand for subscription is very elastic using industry level data for Portugal between 1999 and 2005.}

6 Policy Exercises

In this section, we perform six policy exercises to illustrate the importance of switching costs for the market structure of mobile telephony and to assess their impact on consumer welfare. These exercises are based on simulations using the estimated structural demand model. The results are reported in Table 10. Since market shares do not change substantially over time, we only compute the average annual market shares.

First, we analyze the impact of a price increase. If the prices of all firms increase 10%, the annual consumer surplus, given by (3), decreases by 8.76%.

Second, we analyze the impact of reducing switching costs to zero for all of the firms. Switching costs may be reduced by regulation. However, zero switching costs are rather unrealistic. We treat this case as an upper bound for the largest possible decrease in switching costs. If switching costs are reduced to zero for all of the firms, the market share of Optimus increases by 10% points, mostly at the expense of Tmn,
whose market share decreases by 8% points. However, Tmn still remains with the largest market share. This may be due to either brand preferences, or to Tmn being the cheapest alternative for many consumers, given their usage pattern. If the switching costs are reduced to zero, the annual consumer surplus increases by 44.7%.

Third, we analyze the impact of reducing switching costs to zero for one firm only. In other words, it becomes costless to switch to a given firm, but it remains costly to switch to the other firms. The case where the cost of switching to Tmn is zero results in the largest reallocation of consumers. The market share of Tmn increases by 22% points, mostly at the expense of Vodafone, whose market share decreases by 14% points.

Fourth, we analyze the impact of Tmn and Vodafone setting the same price for mobile telephony services for all consumers, and switching costs being reduced to zero. The market shares of Tmn, Vodafone, and Optimus become, respectively, 37, 34, and 29%. Since consumers value Tmn and Vodafone equally, this shows that the persistence of brand preferences plays an important role in mobile telephony.

Fifth, we analyze the impact of one of the firms setting its price to zero, while switching costs remain at the estimated level. Interestingly, the changes in market shares are smaller than when the cost of switching to the same firms is zero. For instance, if the cost of switching to Optimus is zero and the cost of switching to the other firms remains at the estimated level, the market shares of Tmn, Vodafone, and Optimus are, respectively, 34, 21, and 45%. If the price of Optimus is zero and the prices of the other firms and the cost of switching remain at the estimated level, the market shares of Tmn, Vodafone, and Optimus are, respectively, 46, 29, and 25%.

Sixth, we analyze the impact of setting the prices of both on-net and off-net calls of Tmn equal to the average price of mobile calls. As shown in Table 5, there are substantial differences between the prices of on-net and off-net calls. This gives Tmn a competitive advantage by creating price-mediated network effects. Because most calls are on-net, the average price of mobile calls for Tmn is close to the price of on-net calls. This implies that Tmn is the cheapest firm for many consumers. Consequently, the market shares do not change at all. However, if one assumes in addition that there are no switching costs, the market share of Tmn decreases by 2% points more than in the former case.

These simulations illustrate three important points. First, switching costs are an important element of the market structure of mobile telephony. Even if mobile operators were to set prices to zero, in the short run, only a relatively small share of consumers would switch provider. Second, the persistence of brand preferences is also an important element of the market structure of mobile telephony. Even if the switching costs of all firms were zero, the relative ranking of the firms in terms of market share would remain unchanged. Third, price-mediated network effects are less important than are switching costs and brand preference in the market structure of mobile telephony.

23 The network operator in question may pay consumers the equivalent of their switching costs.
7 Conclusion

In this article, we estimate the price elasticities of demand for subscription and consumer switching costs for mobile telephony. We use data from a panel of about 800 consumers of mobile services in Portugal between April 2003 and March 2004 to estimate several multinomial and mixed logit models.

Our findings show that there is persistence in consumers’ preferences for network operators, but the role of switching costs is more important in explaining customer choices and market shares. Moreover, we find that the demand for subscription is elastic with respect to price, and that the price elasticities vary substantially across firms and their consumers. Switching costs are large and decrease product substitutability.

We also perform policy exercises to illustrate the importance of switching costs and brand preference persistence for the market structure of mobile telephony, and to evaluate the impact switching costs on consumer surplus.

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