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Working Paper #06-22

October 2006

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Merger Simulation in Mobile Telephony in Portugal*

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Abstract

This article assesses the unilateral effects on prices of a merger in the Portuguese mobile telephony market. We use aggregate quarterly data from 1999 to 2005 and a nested logit model to estimate the price elasticities of demand and the marginal costs of subscription of mobile telephony. Given these estimates, we simulate the effects of the merger. We find that the available mobile telephony subscription products are close substitutes. The merger may cause substantial price increases, even in the presence of large cost efficiencies. On average, prices increase by 7% without cost efficiencies, and by about 6% with a 10% marginal cost reduction.

Key Words: *mobile telephony, merger simulation, nested logit, network effects, lock-in*

JEL Classification: L13, L43, L93

*Financial support from the NET Institute, www.NETinst.org and the CEPR RTN Competition Policy in International Markets is gratefully acknowledged. The opinions expressed in this article reflect only the authors' views, and in no way bind the institutions to which they are affiliated.

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1 Introduction

In February 2006, the firm *Sonaecom* proposed an operation that would involve, among other things, the merger of the Portuguese mobile telephony firms *Tmn* and *Optimus*. The Portuguese market includes a third firm, *Vodafone*. The revenue market shares of *Tmn*, *Vodafone*, and *Optimus* are, respectively: 50%, 37%, and 13%. Given that the merger reduces the number of competitors from three to two, and increases considerably the level of concentration, it raises serious anti-competitive concerns.

According to the EC Merger Regulation,[1] mergers must be assessed to determine whether they significantly lessen competition, due to the creation or reinforcement of a dominant position. In economic terms, mergers must be assessed to determine whether they enhance the market power of the firms in the market. Horizontal mergers may significantly lessen competition through: **(i)** unilateral effects, i.e., by eliminating important competitive constraints, or, **(ii)** coordinated effects, i.e., by making anti-competitive coordination between the remaining firms more likely or more effective. This article assesses the unilateral effects on prices of the merger between *Tmn* and *Optimus*.

Our analysis uses aggregate quarterly data from 1999 to 2005. We estimate an aggregate nested logit model, based on a linear utility function for mobile telephony subscription, developed by Doganoglu and Grzybowski (2006).[2] Given the estimates of the price elasticities of demand, and assuming that firms play a Bertrand game, we estimate the marginal costs. We use the estimates of the price elasticities of demand and the marginal costs to simulate the unilateral effects on prices of the merger. Our results indicate that the merger would lead to significant price increases, even in the presence of substantial cost efficiencies. On average, prices increase by 7% without cost efficiencies, and by 6% with a 10% a marginal cost reduction. The price of some products could increase by as much as 13%. On average, without marginal cost efficiencies, the

[1] Council Regulation (EC) No 139/2004 of 20 January 2004 (OJ L 24, 29.01.2004, p.1).

[2] According to Crooke et al (1999), predicted post-merger price changes vary greatly with the demand specification. The price increases predicted by the logit model are lower than those predicted by the log-linear and AIDS models, but higher than those predicted by the linear demand.

consumer surplus and the social welfare decrease both by 3%. We find no evidence of collusion in prices.

There is a growing, but still scarce, econometric literature on merger analysis. Nevo (2000) estimated a random coefficient model to study the effects of mergers in the US ready-to-eat cereal industry. Ivaldi and Verboven (2005) analyzed the effects of the merger between Volvo and Scania in the EU. Pinkse and Slade (2004) used a distance metric approach to study mergers in the brewing industry. Pereira and Ribeiro (2006) analyzed the effects on broadband access to the Internet of the divestiture, the opposite of a merger, of the Portuguese telecommunications incumbent from the cable television industry.

Regarding the empirical literature on mobile telephony, Rodini et al. (2002) estimated the substitutability of fixed and mobile services for telecommunications access, using data on US households. Okada and Hatta (1999) analyzed jointly the demand for mobile and fixed telephony services using Japanese data. Barros and Cadima (2000) estimated simultaneously diffusion curves for mobile and fixed telephony in Portugal. Grzybowski and Doganoglu (2006) used a nested logit model to estimate the demand for subscription of mobile telephony in Germany. Gagnepain and Pereira (forthcoming) analyzed the impact of the entry of a third firm on the Portuguese mobile telephony market, and showed that it caused the other firms to increase their cost reducing efforts.

The remainder of the article is organized as follows. Section 2 gives an overview of the Portuguese mobile telephony industry. Section 3 presents the econometric model and the data. Section 4 presents the estimation results. Section 5 conducts the analysis of the impact of the merger. Section 6 concludes.

2 Mobile Telephony in Portugal

In Portugal, the firm associated with the telecommunications incumbent, *Tmn*, started operations in 1989 with the analogue technology *C*-450. In 1991, the sectorial regulator, *ICP-ANACOM*, assigned two licenses to operate the digital technology *GSM* 900. One of the licenses was assigned to *Tmn*. The other license was assigned to the entrant *Vodafone*. In 1997, the sectorial regulator assigned three licenses to operate the digital technology *GSM* 1800. Two licenses were assigned to *Tmn* and *Vodafone*. A third license was assigned to the entrant *Optimus*, which was also granted a license to operate *GSM* 900. In 2001, the sectorial regulator assigned licences to operate the *3G* technology *IMT2000/UMTS*. Three licenses were assigned to *Tmn*, *Vodafone*, and *Optimus*. A fourth license was assigned to the entrant *Oniway*, which was not granted a license to operate *GSM*, and never operated before. Service began in 2001.

After its inception in 1989, the Portuguese mobile telephony industry had a fast diffusion, analyzed in Pereira and Pernias (2006) and Pereira et al. (2006). In 2005, the penetration rate of mobile telephony in Portugal was 108%.[3]

After entering the market in 1992, *Vodafone* gained revenue market share rapidly. During the duopoly period, i.e., from 1992 to 1997, *Tmn* and *Vodafone* shared the market. The entry of *Optimus* led to an asymmetric split of the market, which suggests that this event had a substantial impact in the industry, analyzed in Gagnepain and Pereira (2006).

In February 2006, the holding company *Sonaecom*, that owns *Optimus*, made an hostile take bid for the holding company *Portugal Telecom*, *PT*, the telecommunications incumbent. The merger of *Tmn* and *Optimus* was one of the conditions for the operation to go through.

3 Econometric Model

3.1 Demand

We assume that all consumers have access to a fixed telephone. Consumers face a two stage decision. In the first stage, they decide whether to continue to use only fixed telephony, or to use also mobile telephony. In the second stage, they decide to which mobile telephony product they subscribe, if they decided to use mobile telephony in the first stage. This is a standard

[3]The penetration rate is the numbers of subscribers per 100 inhabitants.

nested logit structure, where one branch is degenerated and involves no further choices.[4] We index the nests with subscript $g = 0, 1$, where the nest $g = 0$ represents the choice of only fixed telephony, and the nest $g = 1$ represents the choice of fixed telephony and mobile telephony.

We index consumers with subscript i, products with subscript j, and time period with subscript t. Denote by U_{i0t}, the utility of the outside option of consumer i at time t. Value U_{i0t} may vary over time, e.g., due to its dependence on the prices of fixed telephony. There are three mobile telephony products, each associated to one of the three firms currently in the market. The utility derived by consumer i from using fixed telephony together with the mobile telephony product j in period t is given by:

$$U_{ijt} = U_{i0t} + r_j - \alpha p_{jt} + V_t + \xi_{jt} + \zeta_{gt} + (1 - \sigma)\epsilon_{ijt}, \tag{1}$$

where r_j is the stand alone value of product j, p_{jt} is the price of product j in period t, V_t is the expected network benefit function in period t, ξ_{jt} is the unobserved utility of product j in period t, ζ_{gt} is the common value of all products in nest g in period t, σ on $[0, 1)$ is a parameter that measures correlation of the consumers' preferences within the nest fixed telephony and mobile telephony, and ϵ_{ijt} is an idiosyncratic taste variable.

By normalizing with respect to the utility of the outside option, U_{i0t}, the choice between alternatives becomes independent of the determinants of the utility of fixed telephony. The consumer's tastes for products within a nest are correlated. When the consumer's tastes for products within a nest are independent, $\sigma = 0$, the nested logit model reduces to the logit model. When $\sigma \longrightarrow 1$, the alternatives within the nest are perfect substitutes and the post-merger prices do not change. Variable ξ_{jt} is interpreted as the mean value of the consumers' valuations for unobserved product characteristics, such as product quality, and serves as the econometric error term.[5] Variable ζ_{gt} has a distribution dependent on σ, and variable ϵ_{ijt} has

[4]A discrete choice model fits well mobile telephony, because consumers usually have one mobile telephone and the outside option, fixed telephony, is clearly defined. However, nested logit model has the property of independence of irrelevant alternatives within the nests. This property may be tested following Hausman and McFadden (1984).

[5]Prices, stand alone values and unobserved qualities are the only product characteristics in the model.

an extreme value distribution.

The probability that consumer i subscribes to product j in period t is:

$$P_{ijt} = P_{ijt}(g = 1)P_{ijt}\big(U_{ijt} \geq max_{k\in\{1,...,N\},k\neq j}U_{ikt}\big), \tag{2}$$

Denote by D_{gt}, the value of the nest g in period t, defined by:

$$D_{gt} = \sum_{j\in G_g} \exp\left(\frac{\delta_{jt}}{1-\sigma}\right), \tag{3}$$

where G is the set of products in nest g, and $\delta_{jt} = r_j - \alpha p_{jt} + V_t + \xi_{jt}$ is the mean utility level of product j in period t. Expression (2) may be written in a closed form as:

$$P_{ijt} = \frac{\exp\left(\frac{\delta_{jt}}{1-\sigma}\right)}{D_{gt}} \frac{D_{gt}^{1-\sigma}}{1 + \sum_{g=1}^{G} D_{gt}^{1-\sigma}}. \tag{4}$$

Denote by s_{jt}, the share of product j in period t, i.e., the number of consumers that choose product j in period t divided by the number of consumers that make subscription decisions in period t. Probability (2) is equivalent to this share, i.e., $s_{jt} = P_{ijt}$. The share of mobile telephony is given by $s_t = \sum_{j=1}^{N} s_{jt}$. Denote by $\overline{s}_{jt|g=1}$, the share of product j of mobile telephony services in period t, i.e., the number of consumers that choose product j in period t divided by the number of consumers that choose to consume mobile telephony in period t. The share of the outside good, i.e., the number of consumers that choose not to subscribe a mobile telephony product divided by the number of consumers that make subscription decisions in period t is given by $s_{0t} = 1 - s_t = 1 - \sum_{j=1}^{N} s_{jt}$.

Following Berry (1994), we invert the observed market shares to compute the mean utility levels of each product, and treat them as observed utility levels. Using the observed utility level and the specification in (1), we arrive to the following equation:

$$\log(s_{jt}) - \log(1 - s_t) = r_j - \alpha p_{jt} + V_t + \sigma log(\overline{s}_{jt|g=1}) + \xi_{jt}. \tag{5}$$

The utility function (1) represents only consumers whose current choice does not depend on the past, i.e., of consumers that just entered the market, or consumers that where previously in the market but have negligible or no switching costs.

There are three types of consumers: **(i)** consumers that just entered the market, **(ii)** consumers that where previously in the market but are not locked-in to a product, and **(iii)** consumers that where previously in the market and are locked-in to a product. The two first types of consumers choose which product they subscribe. The third type of consumers continue to use the product that they subscribed previously. We lack data on the number of consumers that switch of providers over time, and the choices they make. Thus, regarding the third type of consumers we consider two cases: **(i)** only consumers with contracts are locked-in, and **(ii)** consumers with contracts and 50% of consumers with pre-paid cards are locked-in.[6] Since about 80% of the Portuguese consumers use pre-paid cards, in the first case, the majority of consumers are not locked-in, and may react to price changes. Denote by Z_{jt}, the number of subscribers of product j in period t, denote by Z^l_{jt}, the number of subscribers of product j in period t that are locked-in, and denoted by y_{jt}, the number of consumers that choose product j in period t. We approximate the number of consumers that choose product j in period t by the difference $y_{jt} = Z_{jt} - Z^l_{jt-1}$.

Denote by M_t, the market size in period t, i.e., the number of consumers that can potentially subscribe to mobile telephony in period t. We assume that $M_t = 1.08P_t$, where 1.08 is the penetration rate of mobile telephony in 2005:4, and P_t is the population of Portugal in period t. Denote by m_t, the number of consumers that effectively make subscription decisions in period t. This value is given by $m_t = M_t - \sum_{j=1}^{N} Z^l_{jt-1}$. The share of product j is then given by $s_{jt} = \frac{y_{jt}}{m_t}$.

Denote the by $z_t = \frac{1}{M_t}\sum_{j=1}^{N} Z_{jt}$, the penetration rate of mobile telephony in period t. We assume that due to lags in information transmission, each period consumers only observe the number of subscribers of the previous period. Thus, the expected network benefits are a function of the penetration rate of the previous period: $V_t = V(z_{t-1})$.[7] In addition, we assume that the expected network benefits are a linear function: $V(z_{t-1}) = \beta z_{t-1}$.[8] Network effects

[6] Alternatively, one could assume that all consumers of mobile telephony of the previous period are locked-in.

[7] Of course this begs the question of why consumers do not forecast the contemporary penetration rate. Using z_t in the utility function, which depends on current prices, p_{jt}, would greatly complicate the derivation of the first-order conditions. In addition, values z_t and z_{t-1} are highly correlated.

[8] Consumers also derive network benefits from a fixed line network. Given the linearity of the expected network

are an important aspect of mobile telephony. Ignoring them could lead to overestimating the price elasticities of demand. By making network effects depend on the penetration rate, i.e., the total number of subscribers, we are assuming perfect compatibility between the various mobile telephony products, and the lack of price mediated network effects, due to difference on-net and off-net prices.

Using demand equation (5), the substitution matrix for the nested logit model is given by:

$$S_t = \begin{bmatrix} \frac{\partial s_{1t}}{\partial p_{1t}} & \frac{\partial s_{2t}}{\partial p_{1t}} & \frac{\partial s_{3t}}{\partial p_{1t}} \\ \frac{\partial s_{1t}}{\partial p_{2t}} & \frac{\partial s_{2t}}{\partial p_{2t}} & \frac{\partial s_{3t}}{\partial p_{2t}} \\ \frac{\partial s_{1t}}{\partial p_{3t}} & \frac{\partial s_{2t}}{\partial p_{3t}} & \frac{\partial s_{3t}}{\partial p_{3t}} \end{bmatrix},$$

where

$$\frac{\partial s_{jt}}{\partial p_{kt}} = \begin{cases} -\frac{\alpha}{1-\sigma} s_{jt}\left[1 - \sigma \overline{s}_{jt|g=1} - (1-\sigma)s_{jt}\right] & \text{if } k = j; \\ \frac{\alpha}{1-\sigma} s_{jt}\left[\sigma \overline{s}_{kt|g=1} + (1-\sigma)s_{kt}\right] & \text{if } k \neq j. \end{cases} \tag{6}$$

and

$$\frac{\partial s_{0t}}{\partial p_{kt}} = \alpha s_{kt} s_{0t}. \tag{7}$$

The elements of matrix S_t are calculated using the estimates of σ and α.

Using (6), for the products within the mobile telephony nest, the elasticity of demand of product j with respect to the price of product k is given by:

$$E_{p_{kt}}^{s_{jt}} = \frac{\partial s_{jt}}{\partial p_{kt}} \frac{p_{kt}}{s_{jt}}.$$

Using (7), the elasticity of the market demand for mobile telephony subscription with respect to the price of product j is given by:

$$E_{p_{kt}}^{s_t} = \frac{\partial(1 - s_{0t})}{\partial p_{kt}} \frac{p_{kt}}{s_t} = -\alpha s_{kt}(1 - s_t)\frac{p_{kt}}{s_t}.$$

The elasticity of the market demand for mobile telephony subscription with respect to the lagged penetration rate is given by:

$$E_{z_{t-1}}^{s_t} = \beta z_{t-1}(1 - s_t).$$

benefits function and the linearity of the utility function (1), any network benefits from fixed telephony are cancelled out when we normalize with respect to the outside option.

Following Anderson et al. (1992) and Ivaldi and Verboven (2004), the net consumer surplus for the nested logit model, CS_t, equals:

$$CS_t = \frac{1}{\alpha}\left(1 + \sum_{g=1}^{G} D_{gt}^{1-\sigma}\right). \tag{8}$$

3.2 Supply

We index firms with subscript f. Denote the price vector by $\mathbf{p}$, and the demand for product j by $Q_j(\mathbf{p})$. The profit function for firm f is:

$$\Pi_f = \sum_{j \in \Phi_f} \left[(p_j - c_j)Q_j(\mathbf{p})\right]$$

where Φ_f is the set of products owned by firm f, and c_j is the marginal cost of firm j. Denoted by Δ, the 3×3 ownership matrix, formed according to the rule:

$$\Delta_{fj} = \begin{cases} 1 \text{ if firm } f \text{ sells product } j; \\ 0 \text{ otherwise.} \end{cases}$$

We assume that firms choose prices and play a static non-cooperative game, i.e., a Bertrand game. Additionally, we assume that firms only take into account in the profit maximization problem consumers that are not locked-in. The Nash equilibrium of the game is given by the first-order conditions:[9]

$$\frac{\partial \Pi_f}{\partial p_k} = Q_k + \sum_{j=1}^{J} \Delta_{fj} \frac{\partial Q_j}{\partial p_k}(p_j - c_j) = 0, \tag{9}$$

Denote by $\Delta \bullet S_t$, the Hadamard, or element by element product of matrices Δ and S_t. System (9) can be written in matrix notation as:

$$\mathbf{Q} + (\Delta \bullet S_t)(\mathbf{p} - \mathbf{c}) = 0. \tag{10}$$

Initially, there are three mobile telephony firms: *Tmn*, *Vodafone*, and *Optimus*. Each firm owns one of the mobile telephony products. Thus: $\Delta =$I.

[9] We assume that a Nash equilibrium exists. See Anderson et al. (1992) for a proof of existence for the nested logit model with multiproduct firms, assuming symmetry.

In the course of the analysis, we will assume two alternative forms for the matrix Δ: **(i)** one associated with the merger of *Tmn* and *Optimus*, and **(ii)** one associated with joint profit maximization.

3.3 The Data

We use quarterly data from Portugal for the period 1999:1 to 2005:4, obtained from the firms. For each firm and period, we have: the number of subscribers, Z_{jt}, the number subscribers with pre-paid cards, the number of subscribers with contracts, the revenues from voice traffic, the voice traffic, the operating costs, the cost of materials, the cost of labor, and the number of employees. We also have the interest rate on ten year treasure bonds. We construct average prices, p_{jt}, by dividing the total firm revenues from traffic by the total number of minutes of traffic.

4 Econometric Implementation

4.1 Demand Estimates

We estimate two models.[10] In Model I, only consumers with contracts are locked-in. In Model II, consumers with contracts and 50% of consumers with pre-paid cards are locked-in. Otherwise the models are identical. In particular, in both models the demand for mobile telephony subscription is a function of: **(i)** the average prices, **(ii)** the lagged penetration rate of mobile telephony, and **(iii)** firm specific dummy variables. The price and network coefficients are common across the three demand functions.

[*Table* 1]

Table 1 presents the estimation results for Model I. The model is estimated first using ordinary least squares, *OLS*. Reported R-squared is about 0.60 for each equation. The Breusch-

[10] The model was estimated using the SAS procedure PROC MODEL. The merger simulation was conducted in Matlab.

Godfrey test rejects the null hypothesis of no autocorrelation and the White test rejects the null hypothesis of no heteroscedasticity in all three demand equations. Besides, the estimate of σ is larger than 1, but not statistically significant. To account for the problems of autocorrelation and heteroscedasticity of the error term, and the problem of endogeneity of prices and the within group shares, we estimate the model through the general method of moments, *GMM*, using the Newey and West (1987) consistent covariance matrix estimator. We use as instruments the weighted average across firms of the cost of materials per subscriber, the cost of labor per employee, and the number of workers per subscriber, as well as the interest rate of ten year treasure bonds, a time trend, and a dummy variable for the fourth quarter.[11]

The *GMM* estimates of all parameters are statistically significant. The estimates of α and σ decrease considerably. In particular, σ is estimated to be 0.865, but statistically significantly different from 1. This implies that mobile telephony products are very close substitutes.

Table 1 presents also the estimation results for Model II. The *OLS* estimates are presented merely as a reference. The *GMM* estimates are again all statistically significant. Compared to Model I, the estimate of α increases, and the estimates of σ and β decrease. The estimate of σ is 0.744. However, it is not statistically different from the value 0.865, the estimate of σ for Model I. The estimates of α and β are also not statistically significantly different from the estimates of Model I.

4.2 Price Elasticities of Demand

Table 2 presents the average price elasticities of demand for the *GMM* estimates. The second, third, and fourth columns give the own and cross price elasticities of demand for the mobile telephony products. The last column gives the elasticities of the market demand of mobile telephony with respect to the prices of the mobile telephony products and the lagged

[11]For instruments we need variables that are correlated with prices and within group shares, but uncorrelated with the unobservable demand shocks. Standard candidates for instruments are input factors (Evans and Heckman, 1983).

penetration rate.

[*Table* 2]

For Model I, the own price elasticities of demand are high and range from -2.61 for *Tmn* to -6.32 for *Optimus*. A 1% increase in the price of *Optimus* decreases its sales by 6.32% and increases the sales of *Tmn* and *Vodafone* by 1.33% each. The values in the last column of Table 2 are interpreted as follows. A 1% price decrease in the price of *Optimus* increases the number of subscribers of mobile telephony by 0.06%. This is the outcome of two opposing effects: a decrease in the number of subscribers of *Optimus*, and an increase in the number of subscribers of *Tmn* and *Vodafone*. Similarly for *Tmn* and *Vodafone*. If all firms increase simultaneously their prices by 1%, the number of subscribers of mobile telephony decreases by the sum of these values, which is 0.341%. The small values of the elasticity of the market demand of mobile telephony subscriptions with respect to the prices of the mobile telephony products suggests that mobile and fixed telephony are weak substitutes. If the lagged penetration rate increases by 1%, the number of subscribers increases by 0.99%.

The estimates of the own and cross price elasticities of demand for the mobile telephony products are larger for Model I than for Model II. However, the elasticities of the market demand of mobile telephony subscription with respect to the prices of the mobile telephony products and the lagged penetration rate are larger for Model II than for Model I.[12]

5 Merger Analysis

The merger of *Tmn* and *Optimus* would result in a market with two mobile telephony firms: **(i)** one controlling the two products previously owned by *Tmn* and *Optimus*, to which we shall refer as *Tmn*$-$*Optimus*, and **(ii)** *Vodafone*, which would maintain its product. The merger

[12]The lower the number of locked-in consumers, the larger the share of consumers choosing mobiles, s_{jt}, and the smaller the share of the outside option, s_{0t}. Thus, using equation (6) we get higher own and cross-price price elasticities for the mobile telephony products, but lower elasticities of the market demand for mobiles.

consists of change from matrix Δ to matrix Δ^m, given by:

$$\Delta^m = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

We use the demand estimates in Table 2 to compute the marginal costs given by equation (9), which are presented in Table 3. Then, given these estimates, and replacing Δ with Δ^m, we solve system (10) with respect to prices, to estimate the price of each product after the merger. Table 3 presents the estimated prices after the merger for Model I and II under three scenarios: **(i)** there are no cost efficiencies, **(ii)** there is 5% reduction in the costs of *Tmn* and *Optimus*, and **(iii)** there is 10% reduction in the costs of *Tmn* and *Optimus*.

[*Table* 3]

For Model I, after the merger, the prices of mobile telephony increase on average by 7%. The largest increase, 13%, occurs for *Optimus*, and the lowest, 3%, occurs for *Vodafone*.[13] If the merger generates a 10% reduction in the costs of the merging firms, on average, prices increase by 6%.[14]

The estimates of the price elasticities are smaller for Model II than for Model I. Therefore, the price increases are larger for Model II than for Model I. For Model II, after the merger, the prices of mobile telephony increase on average by 8%.

[*Table* 4]

[13]These simulations ignore adjustments in the consumption levels, i.e., in the number of calls and minutes, resulting from price changes. However, the price elasticities of the demands for calls and duration are very small.

[14]One could also consider the case in which after the merger, the less efficient *Optimus* is able to provide services with the marginal cost level of *Tmn*. This case is, however, unlikely, since the merger is hostile and is conducted by *Optimus*. Besides, it generates implausible results. The price of *Optimus* decreases by 10% and the price of *Tmn* increases by 40%. The price of *Vodafone* remain almost unchanged. This occurs because the post-merger margins are equal for both firms, but the pre-merger margins differ significantly.

Table 4 reports the impact of the merger on profits, consumer surplus, and social welfare, with 95% confidence intervals.[15] For Model I, on average, after the merger the consumer surplus decreases by 4%. The profits of all firms increase, and on average profits increase by 26%. Social welfare decreases by 4%. However, the confidence intervals for changes in profits, consumer surplus, welfare are large and include both positive and negative values. For Model II, the decrease in consumer surplus is larger.

$[Table\ 5]$

We use the information on the operating costs of the firms to asses the plausibility of the assumption that firms play a Nash equilibrium. More specifically, we compare the estimated price-cost margins, $\frac{p_{jt}-\widehat{c}_{jt}^{n}}{p_{jt}}$, with the observed price-cost margins, $\frac{rev_{jt}-opc_{jt}}{rev_{jt}}$, where rev_{jt} is the revenue and opc_{jt} is the operating cost, respectively, of firm j in period t. Table 5 presents simple statistics on estimated and observed margins. Unfortunately, there are large differences between these values. This could be due to the definition of operating costs, which are average accounting costs, rather than economic marginal costs. In particular, the observed margins of *Optimus* are negative. The observed margins of *Tmn* are much higher than those of *Vodafone*.

We also estimated the marginal costs under the assumption that firms maximized jointly their prices. In this case matrix Δ consists only of ones. The estimates of all the marginal costs are negative. Recall that the mobile telephony products are very close substitutes, while the outside product is not a close substitute. We take this as evidence that firms do not collude on prices.

[15] The confidence intervals were computed using a standard bootstrapping method. The covariance matrix of the parameter estimates was used to generate 1000 draws from a joint-normal distribution. For each draw, we computed the percentage change in post-merger profits, consumer surplus, and welfare, relative to the pre-merger situation. In this way we got a distribution of potential profit changes.

6 Conclusion

In this article we simulated the unilateral effects of a merger in the Portuguese mobile telephony market. We estimated the price elasticities of demand using a nested logit model and quarterly data from 1999:1 to 2005:4. The mobile telephony subscription products seem to be close substitutes. Using the estimates of the price elasticities of demand and the assumption that firms play a Bertrand game we estimated the marginal costs. We used the estimates of price elasticities of demand and the marginal costs to simulate the unilateral effects of a merger between *Tmn* and *Optimus*. We found that the merger can lead to substantial price increases even with cost efficiencies.

In mobile telephony, the complexity of the consumers' behavior and the firms' strategies is very challenging for economic modelling. However, we had only limited aggregate data, which constrained the sophistication of our analysis. In addition, competition authorities or sectorial regulators usually have limited resources, such as time and personnel, to collect data and evaluate the merger effects. This is a compelling argument for using simple methods.

There is scarce evidence of the accuracy of merger simulations, due to the small number of cases in which simulations were conducted. The merger in mobile telephony in Portugal is a natural experiment that, in case of acceptance, can be used to assess whether standard analysis of this type may provide us with accurate predictions about unilateral effects.

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Appendix

Table 1: Demand Estimates

Model I	OLS Estimates	std (t)	GMM Estimates	std (t)
r_{opt}	1.141	2.769 (0.41)	-1.886	0.304 (-6.20)
r_{tmn}	-0.656	1.564 (-0.42)	-2.153	0.123 (-17.43)
r_{vod}	0.984	2.432 (0.40)	-1.804	0.285 (-6.32)
α	-9.644	4.464 (-2.16)	-3.258	1.302 (-2.50)
σ	1.676	1.081 (1.55)	0.864	0.118 (7.31)
β	5.645	0.647 (8.72)	4.753	0.311 (15.27)
mse/R-sq Opt.	0.9249	0.59	1.0496	0.51
mse/R-sq Tmn	1.0511	0.57	1.0800	0.52
mse/R-sq Vod.	0.9363	0.63	1.0863	0.53
N*Obj.	72.8092		7.2117	
Model II	**OLS Estimates**	**std (t)**	**GMM Estimates**	**std (t)**
r_{opt}	-0.158	2.395 (-0.07)	-2.470	0.186 (-13.25)
r_{tmn}	-1.539	1.408 (-1.09)	-2.671	0.075 (-35.54)
r_{vod}	-0.141	2.157 (-0.07)	-2.323	0.214 (-10.83)
α	-9.176	4.409 (-2.08)	-3.767	1.489 (-2.53)
σ	1.322	0.970 (1.36)	0.743	0.139 (5.34)
β	5.515	0.657 (8.39)	4.628	0.321 (14.40)
mse/R-sq Opt.	0.9604	0.57	1.0453	0.49
mse/R-sq Tmn	1.0249	0.56	1.0807	0.51
mse/R-sq Vod.	1.0103	0.60	1.1062	0.51
N*Obj.	74.8365		8.9926	

Table 2: Demand Elastictites: Price and Lagged Subscribers

Model I	Optimus	TMN	Vodafone	Mobiles s_t
Optimus	-6.32	1.33	1.33	-0.063
TMN	2.44	-2.61	2.44	-0.170
Vodafone	2.47	2.47	-5.86	-0.108
Net.Effect				0.985
Model II	**Optimus**	**TMN**	**Vodafone**	**Mobiles s_t**
Optimus	-3.93	0.75	0.75	-0.088
TMN	1.37	-1.71	1.37	-0.234
Vodafone	1.39	1.39	-3.71	-0.144
Net.Effect				1.365

Table 3: Simulation of Post-Merger Equilibrium Prices

Model I	p.pre	mc ef.0%	markup%	p.post	price %
Optimus	0.2924	0.2257	0.2283	0.3353	0.1288
Tmn	0.1881	0.1044	0.4450	0.2140	0.1200
Vodafone	0.2939	0.2137	0.2729	0.3056	0.0349
mean	0.2380			0.2566	0.0713
	p.pre	mc ef.5%	markup%	p.post	price %
Optimus	0.2935	0.2144	0.2695	0.3291	0.0985
Tmn	0.1896	0.0992	0.4769	0.2139	0.1042
Vodafone	0.2948	0.2137	0.2753	0.3045	0.0261
mean	0.2389			0.2565	0.0641
	p.pre	mc ef.10%	markup%	p.post	price %
Optimus	0.2923	0.2031	0.3052	0.3195	0.0721
Tmn	0.1888	0.0940	0.5022	0.2103	0.0946
Vodafone	0.2943	0.2137	0.2740	0.3019	0.0196
mean	0.2378			0.2531	0.0565
Model II	p.pre	mc ef.0%	markup%	p.post	price %
Optimus	0.3131	0.2257	0.2794	0.3686	0.1684
Tmn	0.2164	0.1044	0.5174	0.2474	0.1378
Vodafone	0.3178	0.2137	0.3277	0.3317	0.0416
mean	0.2307			0.2490	0.0772
	p.pre	mc ef.5%	markup%	p.post	price %
Optimus	0.3144	0.2144	0.3182	0.3622	0.1448
Tmn	0.2177	0.0992	0.5444	0.2470	0.1310
Vodafone	0.3192	0.2137	0.3306	0.3316	0.0371
mean	0.2314			0.2489	0.0736
	p.pre	mc ef.10%	markup%	p.post	price %
Optimus	0.3115	0.2031	0.3480	0.3493	0.1137
Tmn	0.2139	0.0940	0.5606	0.2402	0.1186
Vodafone	0.3158	0.2137	0.3233	0.3260	0.0304
mean	0.2299			0.2455	0.0664

Table 4: Simulation of Post-Merger Equilibrium Profits, Consumer Surplus and Welfare

Model I					Mod.II			
	pre	Δx	$1-\alpha=0.95$	%	pre	Δx	$1-\alpha=0.95$	%
Optimus	0.0148	0.0014	[0.0000, 0.0051]	9,5%	0.0166	0.0013	[0.0002, 0.0033]	7,8%
Tmn	0.0303	0.0072	[-0.0000, 0.0254]	23,8%	0.0379	0.0079	[-0.0000, 0.0161]	20,8%
Vodafone	0.0272	0.0105	[0.0000, 0.0345]	38,6%	0.0312	0.0113	[0.0003, 0.0219]	36,2%
CS	4.5937	-0.2009	[-0.4994,-0.0000]	-4,4%	2.0070	-0.1289	[-0.1983,-0.0038]	-6,4%
Welfare	4.6661	-0.1819	[-0.4431,-0.0000]	-3,9%	2.0927	-0.1084	[-0.1652,-0.0031]	-5,2%
Optimus	0.0149	0.0039	[0.0007, 0.0093]	26,2%	0.0170	0.0033	[0.0023, 0.0067]	19,4%
Tmn	0.0309	0.0077	[-0.0001, 0.0283]	24,9%	0.0384	0.0085	[-0.0000, 0.0153]	22,1%
Vodafone	0.0273	0.0085	[-0.0069, 0.0359]	31,1%	0.0317	0.0102	[-0.0004, 0.0201]	32,2%
CS	4.4662	-0.1566	[-0.5112, 0.1425]	-3,5%	1.9921	-0.1170	[-0.1849, 0.0080]	-5,9%
Welfare	4.5392	-0.1364	[-0.4438, 0.1394]	-3,0%	2.0792	-0.0949	[-0.1462, 0.0122]	-4,6%
Optimus	0.0143	0.0068	[0.0035, 0.0179]	47,6%	0.0165	0.0058	[0.0040, 0.0147]	35,2%
Tmn	0.0306	0.0078	[-0.0003, 0.0276]	25,5%	0.0371	0.0087	[-0.0001, 0.0150]	23,5%
Vodafone	0.0273	0.0067	[-0.0095, 0.0311]	24,5%	0.0308	0.0084	[-0.0021, 0.0168]	27,3%
CS	4.3214	-0.1187	[-0.4569, 0.2056]	-2,7%	2.0642	-0.0986	[-0.1626, 0.0384]	-4,8%
Welfare	4.3937	-0.0973	[-0.3979, 0.2016]	-2,2%	2.1487	-0.0757	[-0.1267, 0.0473]	-3,5%

Table 5: Observed and Estimated Price-Cost Margins

	mean	std	min	max
obs_{opt}	-0.137	0.160	-0.71426	0.08068
obs_{tmn}	0.223	0.068	0.03140	0.34624
obs_{vod}	0.071	0.076	-0.16373	0.15950
est_{opt}	0.160	0.022	0.13518	0.24609
est_{tmn}	0.390	0.053	0.30918	0.46351
est_{vod}	0.173	0.023	0.14230	0.23966