Merger simulation using average market share: an application to the Optimus-TMN mobile merger case

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ABSTRACT

This paper develops a new merger simulation methodology based on the analysis of the performance change of a hypothetical firm with average market share. It applies the methodology to the Optimus-TMN mobile telecom merger case in Portugal, within the context of the December 2006 decision by the Portuguese Competition Authority to authorize the merger between their respective parent companies, Sonaecom and Portugal Telecom. The results suggest that the Optimus-TMN merger would have resulted in 3.8% higher prices and 14.9% lower marginal costs, and would have been welfare-enhancing. Our results attest to the importance of the “efficiency defense” hypothesis of mergers. They suggest that competition authorities are warranted in allowing further consolidation in the telecom sector, but that consolidation should be accompanied by strict retail price-cap regulation.

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1. Motivation

In contrast with the natural monopoly principle that guided the regulatory oversight of fixed network incumbents until the 1980s, from the outset of digital mobile telecommunications in the early 1990s, regulators promoted competition as a means to improve industry performance. The rapid industry growth experienced in the 1990s and early 2000s, in a sense vindicated the regulatory approach and resulted in a growing preference for allowing market forces to determine outcomes and in a less prominent role for regulation in the sector, particularly regarding the retail market. On the one hand, the regulators attempted to create conditions that facilitated new entry, namely through wholesale market regulation, though, as the industry matured, there have been fewer instances of large scale entry. On the other hand, regulators have, for the most part, refrained from retail price regulation. In addition, they have accepted reductions in the number of competitors, even when these led to large increases of the Herfindahl-Hirschman index (HHI), seen as problematic by the standards of earlier decades.[1]

However, mobile telecommunication mergers pose a challenge to the prevalent regulatory policy, since there is an inherent contradiction on relying on competition to ensure efficient outcomes while simultaneously allowing further industry consolidation.

Merging parties typically argue that merger proposals are driven by efficiency gains and by quality improvements that benefit consumers, such as expanded network coverage or the ability to invest in better technology. Nonetheless, these claims should be seen with some skepticism: after all, merger proposals are subject to regulatory review and approval. Merger regulations in the US and in the EU prohibit mergers that result in impediments to “effective competition”. Therefore, it can hardly be expected that merger parties put forward a merger rationale based on market power claims.

Enhanced efficiency and quality are outcomes that are acceptable and desirable from a policy maker perspective. Williamson (1968) was the first to argue that antitrust authorities should account for efficiency gains in evaluating mergers, and should be careful in disallowing mergers even with modest efficiency gains. Moreover, a large body of literature argues that mergers are, to a large extent, driven by efficiency gains (Salant *et al*., 1983; Levin, 1990; Farrel and Shapiro, 1990). Regulators, on the other hand, will be concerned and likely oppose the merger if the rationale for the merger lies in increased market power (and higher prices). Indeed, merger regulations tend to focus on the effect of mergers on "effective competition" and on prices, and only recently have started to take into account efficiency gains. For example, only starting with the 1997 revision of the DoJ-FTC Horizontal Merger Guidelines, were parties "invited" to offer efficiency claims, and prior to that date antitrust agencies and courts rejected efficiencies as a positive factor (Parisi, 2009). In the European Union, a provision to take into account efficiencies in merger cases was only adopted as part of the 2004 EC Merger Regulation reforms (Parisi, 2009).

In recent years, in western countries, we are unaware of a single instance of a mobile telecommunications merger proposal failing to be authorized by the regulatory authority. While we should be careful about generalizations, given the latitude of remedies imposed to authorize these mergers, these decisions can be interpreted as indicating that regulators do not consider the market power effects of the merger significant nor do they see "impediments to effective competition".

In addition, to the extent that the "efficiency defense" is explicitly or implicitly taken into consideration, these decisions suggest regulators at least partly agree with the efficiency gains and quality improvement claims put forward by merging parties (Williamson, 1968).

This discussion gives rise to three questions. First, is mobile industry consolidation driven by efficiency gains or added market power? Second, are regulators warranted in authorizing further mergers in this industry? Third, what are the implications for the regulatory approach of the sector?

If industry consolidation is driven by efficiency gains, then regulators may be warranted in authorizing further mergers. However, increasing efficiency may suggest that the industry is a natural monopoly, in which case it would have to be regulated as such. Among other things, this suggests some type of retail price regulation would be required. Thus, if mergers are driven by efficiency gains, then the regulatory approach towards the sector may have to be revisited.

On the other hand, if mergers are driven foremost by market power gains, they are prohibited under current merger laws. In that case, regulators are not warranted in authorizing further mergers and the industry's merger review process may have to be rethought.

In order to address these questions, we use an international dataset of mobile operators and analyze the December 2006 decision by the Portuguese Competition Authority (hereafter PCA) to authorize the €10.5bn (later revised to €11.6bn) merger offer of Sonaecom for Portugal Telecom (PT). The decision is interesting because it authorized the creation of a duopoly in three of the relevant markets associated with the mobile network[2] subsidiaries of the two groups, Optimus and TMN, respectively, with a combined 2006 subscriber market share of approximately 64%. It would have resulted in an increase of Portugal's mobile communications market HHI from approximately 3650 to 5400 (based on pre-merger market shares). In defense of the merger, Sonaecom claimed that the Optimus-TMN merger would result in substantial efficiency gains and no price effects due to existing "market conditions" (Autoridade da Concorrência, 2006a).

The merger proposal was considered hostile by the targeted group, PT, owner of TMN. After a one-year long merger process, the PT shareholders rejected a motion to change the bylaws regarding voting restrictions and, as a result, the merger failed. Nonetheless, the PCA decision provides an interesting and unique test case for evaluating the "efficiency defense" of the mobile telecommunications industry consolidation process (Williamson, 1968). It is the only known instance where a duopoly would have resulted from an authorized merger.

The paper has two main contributions. First, by providing evidence that increased market concentration, measured by the average market share, results in higher average industry efficiency, and by applying these results to show that the Optimus-TMN merger would have been both efficiency and welfare enhancing, this paper provides part support, on "efficiency defense" grounds, for the past regulatory policy stance of allowing further industry consolidation. On the other hand, by finding that increases in market concentration result in higher retail prices, the paper suggests that retail price-cap merger remedies are warranted.

The second main contribution is the novel merger simulation methodology based on average market share that is developed in order to answer the research questions of the paper. Our approach is inspired by Williamson's (1968) "efficiency defense" of mergers and his argument that merger analysis requires the consideration of both efficiency gains and market power effects through the estimation of the change in producer's surplus, consumer's surplus, and total welfare (Williamson, 1968; Stewart and Kim, 1993). Indeed, the research questions we ask cannot be answered with the now near-standard Baker-Bresnahan approach towards merger simulation, since it is based either on the assumption that pre- and post-merger marginal costs are identical, i.e., there are no merger efficiencies, or on the hypothesis of a given variation in marginal costs (Baker and Bresnahan, 1985; Nevo, 2000; Ivaldi and Verboven, 2005; Grzybowski and Pereira, 2007).[3]

For example, Grzybowski and Pereira (2007) analyzed the Optimus-TMN merger using the Baker-Bresnahan methodology. They find a +7.1% effect on prices (base estimate), with constant marginal costs, or a +5.7% effect, if a 10% marginal cost reduction is assumed.

In this paper, we estimate a +3.8% effect of the merger on prices and a -14.9% effect on marginal costs. Thus, our results on the price effect are fairly similar to those of Grzybowski and Pereira, but likely because our estimated efficiency gains are larger (-14.9%) than those assumed in Grzybowski and Pereira's sensitivity analysis (-10%), our estimated price increase is lower.

Because of the methodology adopted, the prior work on the Optimus-TMN merger by Grzybowski and Pereira, while providing important evidence of the merger's detrimental effect to prices, is not able to determine whether the merger was efficiency and welfare enhancing. Indeed, the Baker-Bresnahan methodology may under-estimate potential efficiency gains and therefore be biased towards the rejection of mergers. Our work, independently supports Grzybowski and Pereira's results, but complements it by estimating the effect of the merger on producer's surplus and welfare.

Moreover, in contrast to the Baker-Bresnahan approach, the methodology proposed here has low data requirements, and is comparatively simple to be implemented econometrically. In addition, the literature is enriched and the merger decision process becomes more robust if single-merger cases are analyzed using different methodologies.

The structure of the paper is as follows. In Section 2, we provide some background on the merger parties and on the applicable regulatory framework. Then, in Section 3, we estimate the effect of increasing average market share on prices and price-cost margins, using an international dataset of mobile operators with roughly 1700 observations. The estimates are used to predict the post-merger average industry price and price-cost margin if the merger had indeed occurred in the Optimus-TMN case. Section 4 evaluates the industry marginal-cost variation. We then use both an isoelastic demand specification and estimates of the price elasticity of demand for mobile-voice calls in Portugal by Pereira and Ribeiro (2007), in order to infer what would have been the change in the industry output in Portugal. Next, in Section

5, we calculate the Marshallian consumer's surplus change, the deadweight welfare loss, the producer's surplus change, and the overall welfare effect of the merger. In Section 6, we outline the main issues with the proposed methodology. Section 7 reviews the Optimus-TMN aspects of the regulatory decision. Section 8 concludes and discusses the policy implications.

2. Background

The merger target, Portugal Telecom, is the largest business group in Portugal. It is a formerly State-owned, and from 2000 onwards, fully privatized incumbent telecommunications operator. Its core activities include the provision of fixed and mobile telecommunications, internet access, and cable TV services. During the 1990s it expanded internationally, with the acquisition of mobile subsidiaries in Brasil and Africa. It had revenues of €6.3bn in 2006, which made it approximately 7.6 times larger than the acquirer, the Sonaecom group.

Sonaecom is a newspaper, IT, and telecommunications holding. It is itself a subsidiary of one of the largest privately-owned conglomerates in Portugal, Sonae. It grew rapidly particularly following the launch of its own mobile operator subsidiary, Optimus, in 1998.

On February 20th, 2006, Sonaecom notified the PCA of its takeover offer for PT. It is important to note that within the European Union (EU), merger control authority is shared between the European Commission (EC) and the EU member states. According to the EC Merger Regulation (ECMR), the EC has "exclusive jurisdiction" over mergers of a "community dimension". Community dimension is measured by world-wide, EU-wide, and three-member-state-wide combined "turnover" (i.e., revenues less sales or value-added taxes) of the merging companies. In essence, the ECMR requires the merging parties to have significant turnover in at least three member countries or in the EU, and not to have more than two thirds of their joint turnover in a single member country. While PT had large subsidiaries in Brazil and Africa, PT and Sonaecom had no significant presence in other EU countries. Roughly 67% of their combined turnover originated in Portugal. Thus, according to the ECMR, the merger fell under the competency of Portugal's merger control laws.

According to Portugal's competition law, the PCA had the sole authority to review the merger, but was required to obtain expert opinions of the sector-specific regulators, which for nearly all of the relevant markets was ICP-ANACOM, the national telecommunications regulator. The law, however, did not require the PCA to heed to the opinion of the sectorial regulator. In fact, the PCA final decision to authorize the merger was issued despite opposing expert opinion by the ICP-ANACOM.

Both ECMR and Portugal's competition law base their evaluation of mergers on whether the merger will result in impediments to "effective competition", but efficiency concerns have been adopted in the ECMR in 2004 by the Council of the European Union. The PCA also considered the efficiency gains claims put forward by Optimus in its decision process (Autoridade da Concorrência, 2006a).

3. Merger impact on industry price and price-cost margin

Applied merger analysis typically involves three distinct parts (Nevo, 2000). In the first part, the pre-merger market performance is modeled and estimated. In the second part, the merger simulation is carried out by extrapolating the effect of a change in the post-merger market structure on the post-merger market performance. In the third part, which is presented in Section 5, differences in pre- and post-merger market performance are used to estimate the welfare effect of a merger.

Market-concentration measures are typically relevant for the first two parts of merger analysis.[4] First, they are often used as explanatory variables in the modeling part of the merger analysis, in part rooted in their role in the Structure-Conduct-Performance Paradigm

(SCPP). In addition, market concentration measures are used to describe the change in the market structure that results from the merger. In fact, the simulation part of the merger analysis consists of plugging the post-merger concentration variable value in the previously estimated model, in order to estimate the post-merger market performance.

The HHI is commonly regarded as "the" measure of market concentration, though other measures of market concentration are available, including concentration ratios and the inverse of the number of firms in the market, i.e., the average market share. In this paper, the chosen concentration measure is the average market share rather than the HHI, for reasons that we explain further below.

Our methodology requires pre- and post-merger average market share, average prices, average marginal costs, industry output, as well as industry demand elasticity. As shall be seen below, the post-merger data are estimated on the basis of the performance change of a hypothetical average firm following the merger.

The first part of the merger analysis consists of using two SCPP-type reduced-form models that establish the relationship between firm market share and firm price and price-cost margin for the pre-merger market. Our approach has some similarities to that of Stewart and Kim (1993):[5]

(1) $$\ln P_{icyq} = \alpha_0 + \alpha_1 MSHARE_{icyq-1} + \alpha_2 CHURN_{icyq-1} + \alpha_3 MPP_{icyq} + \alpha_c + \alpha_y + \alpha_q + \xi_{icyq}$$

(2) $$EBITDA_{icyq} = \beta_0 + \beta_1 MSHARE_{icyq-1} + \beta_2 CHURN_{icyq-1} + \beta_c + \beta_y + \beta_q + \zeta_{icyq}$$

where $\ln P_{icyq}$ is the logarithm of the price, measured as the average revenue per minute (ARPM) of the firm i in the country c during the quarter q of the year y; $MSHARE_{icyq-1}$ is the lagged market share (the ratio of the number of subscribers for the firm i to the total number of subscribers in the country c); CHURN_{icyq-1} is the lagged churn rate (the percentage of subscribers that cancel their contract in a given quarter), which is thought to be a significant cost factor in the mobile-voice industry;[6] MPP_{icyq} is a dummy variable that controls for countries where the regulatory framework is based on mobile party pays;[7] EBITDA_{icyq} is the EBITDA margin (hereafter just EBITDA), a proxy for the price-cost margin, defined as earnings before interest, taxes, depreciation, and amortization divided by total operational revenues; α_c, α_y, α_q, β_c, β_y and β_q are vectors containing country (c), year (y) and quarter effects (q); and finally ξ_{icyq} and ζ_{icyq} are random disturbances.

We include market shares and churn rates with lags in our models because it is reasonable to think that, in practice, firms devise current-period pricing and mark-up plans on the basis of market data from earlier periods. Specifically, we use values for the previous quarter.

The use of lagged independent variables is also useful to deal with endogeneity issues in the econometric estimation because it avoids simultaneity. It is clear, indeed, that the price level (or the price-cost margin) at quarter q of year t cannot imply any variation of the market share (or of the churn rate) at quarter q-1 of year t.

Ideally, we would like to estimate the contemporaneous impact of the market share (or of the churn rate) on the price level (or on the price-cost margin). Because of simultaneity (reverse causality), the OLS estimator would lead to inconsistent estimates. A solution would be the use of an instrumental-variable approach, but this would require the presence of suitable instrumental variables in the dataset, which is not the case. Another solution is to use, as regressor, the closest proxy of the market share (or of the churn rate) which is not contemporaneously affected by the price (or by the price-cost margin). This is what we do.

We do not explicitly control for market concentration because any measure of market concentration is a market-share dependent covariate. For instance, let us consider again the standard HHI. It is a function of the market share s, say $\mathrm{HHI} = f(s)$. We do not include it because we want to capture the total impact of the market share on the dependent variable through the market-share coefficient (our key coefficient). If a market-share dependent covariate is introduced in our regression models, then part of the effect of the market share on the dependent variable (either on price or price-cost margin) is captured by the market-share dependent covariate. Formally, if the model is $Y = \rho_1 s + \rho_2 \mathrm{HHI}$, then $\frac{\partial Y}{\partial s}$ is not equal to the coefficient ρ_1. Rather, it is equal to $\rho_1 + \rho_2 \frac{\partial f}{\partial s}$.

Our dataset is extracted from the Merrill Lynch's (hereafter ML) Global Wireless Matrix 2Q04 report and contains quarterly data on 177 firms across 45 countries, from the first quarter of 1999 (1Q99) to the second quarter of 2004 (2Q04). Summary sample statistics are reported in Appendix A.

We use international data since our dataset only contains full data for two of the three existing firms in Portugal, Vodafone and TMN. The third operator, Optimus, drops out because of missing observations on the churn-rate regressor. Therefore, we feel it is inappropriate to use data regarding only two firms (42 observations) to draw inferences about what would have been the welfare impact if the number of firms in the Portuguese market would have gone from 3 to 2.

An important advantage of using international data is that the coefficient estimates can also be used to draw inferences on the effect of increasing market concentration on efficiency (marginal costs) and market power (prices) for the entire sample of countries. So our results can be used to derive policy implications regarding the effect of further industry consolidation and address the research questions set out in this paper.

In fact, the estimated impacts on prices and margins control for market size and other country-specific characteristics using country-fixed effects (c). These estimates can be used to simulate the welfare effects of a merger in other countries. For any given country, the methodology requires data on the number of firms in the market (i.e., average market share), industry demand elasticity, the industry output (minutes of traffic), the industry average price, and the industry average price-cost margin. The welfare effects vary across countries depending on these characteristics. Thus, market-size issues are implicitly considered in the analysis.

The estimation results, based on the OLS estimator, are presented in Table 1 and 2. To summarize, we find that a one percentage-point increase in the average market share results in a 0.7 percentage-points increase in the average market margin and in a 0.2% increase in the average market price. If we consider the Eurozone sub-sample (or an OECD sub-sample), the effects are even larger. Specifically, a one percentage-point increase in the average market share results in a 1.1 (0.7) percentage-points increase in the average margin and a 0.5% (0.4%) increase in the average price. Appendix B discusses alternative estimation approaches and results, explaining why we base the next steps of our merger analysis on OLS estimates.

- Table 1 and 2 about here -

The methodology we propose for the merger-simulation part is based on the use of the average market share as the concentration measure that describes the change in pre- and post-merger market structure. The average market share is the inverse of the number of competing firms in the industry and conveys important information about market concentration (see below).

Our approach is as follows. If the number of firms in the Portuguese market falls from 3 to 2 because of a merger, then the average market share increases by 16.7 percentage points.

Multiplying this change by our market-share coefficient estimates obtained from (1) and (2), we obtain an estimate of the expected change in both average price and average margin, respectively, when the average market share increases. In practice, the approach, like prior literature (Salant *et al*., 1983), compares two static long-run equilibria: the basis scenario of the pre-merger three-firm oligopoly (Optimus, TMN and Vodafone Portugal) with the duopoly structure that would have resulted, had the merger been successful. The empirical results suggest that, if the average market share were to increase from 33.3% to 50%, the average price would have increased by 3.8% and the average margin would have increased by 11.6 percentage points. For comparison, Grzybowski and Pereira (2008), using Portuguese mobile telecommunications data, estimate that the proposed Optimus-TMN merger would have increased the average price by 5.7% to 7.1%.

The use of the average in the appraisal of the merger effects is novel, to the best of our knowledge, and is a way of dealing with four issues. First, we know with certainty what would have occurred to the average market share if the merger would have gone ahead. Specifically, in the Optimus-TMN case, the number of firms would have fallen from three to two and, as a consequence, the average market share would have risen from 33.3% to 50%.

The same cannot be said if the HHI is used as the concentration measure to simulate the pre- and post-merger market structures. As pointed out by Salant *et al*. (1983), Perry and Porter (1985), as well as by Farrell and Shapiro (1990), following a merger, the merged parties reduce the output, while the parties that are external to the merger increase the output, even when the resulting oligopoly is strongly asymmetric. Thus, the combined pre-merger market share is not a good predictor for the post-merger market share of the merging firms. Likewise, the post-merger market share of the non-merging firms is likely to increase. Thus, estimates of post-merger HHI, based on pre-merger market shares, are likely to over-estimate post-merger market concentration. Therefore, if HHI is used to describe the change in market structure, one is likely to obtain estimates of welfare effects that are biased.

Second, for a similar reason, it is incorrect to simulate each firm post-merger performance on the basis of its predicted post-merger market share, leading to incorrect industry estimates. The approach suggested here of estimating the post-merger performance of a hypothetical firm with average market share circumvents this issue.

Third, the proposed methodology does not rely on individual firm performance data, which is often confidential or difficult to obtain. Existing merger simulation approaches are typically based on adding up or averaging out the change in performance for each firm in order to calculate change in industry performance. Apart from the uncertainty regarding post merger firm market share, lack of data may make such an approach unviable, or only viable for researchers with access to confidential data.

The use of a hypothetical firm with average market share again circumvents this issue, since average firm performance can be calculated from industry performance and vice-versa. Specifically, in the Optimus-TMN merger case, pre-merger output (minutes of outgoing calls) for each firm is not known in our ML dataset but total pre-merger industry output is known (provided by ICP-ANACOM, 2005a). Average firm price and marginal cost is equal to average industry price and marginal cost, respectively. Average firm demand elasticity is equal to the industry demand elasticity. Thus, the impact of the merger on consumer's surplus, producer's surplus, and welfare can be directly estimated from the average firm's performance change.

Finally, since the proposed merger would have resulted in a duopoly with an above-average and a below-average firm, it is still possible to make general inferences on the performance (prices and margins) of these firms relative to a hypothetical average firm.

On the other hand, by using the average there is a loss of information on the distribution of firms sizes, as a merger between two large firms has the same theoretical effect as a merger between two small firms. Indeed, we are aware that the average conveys little information about the performance of each firm, nor does it indicate how the estimated producer's surplus is going to be split among the post-merger firms.

4. Merger impact on industry marginal cost and output

The estimation of the marginal-cost variation is made by comparing prices and price-cost margins before and after the merger. Note that we use first half of 2004 data as pre-merger data because they are the latest data available in our dataset. Specifically, we have a measure of the initial non-weighted average price-cost margin for the Portuguese mobile telecommunications market in 2004 (the average EBITDA of the operators), which is 35.6%, and a measure of the average price, which is €0.197 per minute. Using the results of Section 3, we estimate that the expected long-run average margin in the Portuguese market would have increased to approximately 47.2%[8], and the average price to €0.205.

Since we know initial and final average prices (P_0 and P_1) and average margins ($EBITDA_0$ and $EBITDA_1$), it is possible to estimate the reduction in the average marginal cost ($c_1 - c_0$) using the following approximations:

$$(3) \qquad \frac{P_0 - c_0}{P_0} \approx EBITDA_0 \qquad\qquad \frac{P_1 - c_1}{P_1} \approx EBITDA_1$$

where the subscript 0 (1) is for the price, the marginal cost and the margin before (after) the merger.

Substituting the prior results in (3), we estimate that the Optimus-TMN merger would have resulted in a post-merger marginal cost of €0.108 per minute, that is, €0.019 less than the pre-merger marginal cost of €0.127. Thus, the merger would have implied a -14.9% effect on marginal costs.

To infer the output variation consistent with the change in the average price, we use an isoelastic demand curve (Hausman, 1997) and estimates of the price elasticity of demand for minutes of mobile telephony calls in Portugal due to Pereira and Ribeiro (2007).

Specifically, we assume that the demand curve is given by:

$$(4) \qquad Q = AP^{-\varepsilon}$$

where A is a demand shifter, Q is the industry output measured as minutes of voice traffic, P is the average price per minute of voice call, and ε is the price elasticity of demand.

Pereira and Ribeiro (2007) estimate the own-price elasticity of demand for TMN, Vodafone, and Optimus, at 1.3, 2.2, and 3.3, respectively. Thus, we use the non-weighted average of Pereira and Ribeiro's own-price elasticities of demand, 2.3, as our measure of the Portuguese market's price elasticity of demand, ε.

As pointed out by an anonymous referee, there is some loss of information as the proposed methodology averages out differences in perception regarding each of the operators, specifically concerning differing own-price demand elasticities. However, as equation (4) suggests, we only need an estimate of the industry demand elasticity in order to estimate the impact of the merger on industry output and welfare (see also Section 5). The differences in perception regarding each of the operators are only relevant to the extent that they affect the industry demand elasticity (weighted vs. non-weighted average). Other than that, and contrary to the Baker-Bresnahan methodology, firm own-price demand elasticities are not required, since individual firm performance is not explicitly modeled in the methodology proposed here. Finally, Section 6 also shows that our qualitative results are robust to changes in industry demand elasticity.

We solve equation (4) to determine the parameter A for Portugal, using pre-merger industry data on output and price. Particularly, as stressed before, first half of 2004 price data from the ML dataset indicate that the average (non-weighted) nominal average price per minute (P) in Portugal is €0.197 per minute, while the total industry output (Q) in 2004 is 14487 million minutes, according to ICP-ANACOM (2005a).[9] Therefore, we evaluate the pre-merger parameter A at $345.3 = 11487\,(0.197)^{2.3}$.

In order to estimate the change in the industry output associated with the change in average price, we assume, like prior theoretical and empirical literature (Salant *et al*., 1983; Farrell and Shapiro, 1990; Levin, 1990; Stewart and Kim, 1993), that the demand curve does not shift as a result of the merger, i.e., the parameter A does not change because of the merger.

As argued in the previous Section, the average market price would have risen by 3.8% to €0.205 per minute. Therefore, equation (4) suggests that the total industry output would have diminished by 8.2% (or 1191 million minutes) to 13296 million minutes. This is roughly 119 fewer minutes per subscriber per year.

5. Merger welfare analysis

The estimation of consumer's surplus and welfare changes has been an important tool in guiding merger analysis in the last decades (Harberger, 1971; Willig, 1976; Motta, 2004; Brito and Catalão-Lopes, 2006), despite criticisms about the concept of consumer's surplus (Harberger, 1971; Hausman, 1981).

Generally, mergers are regarded as detrimental to society if they result in large deadweight welfare losses or alternatively in large transfers of consumer's surplus to producers. They are regarded as beneficial if they result in large producer efficiency gains with limited impact on prices, and thus on consumer's surplus. In this Section, we use the results of the prior two Sections to infer the impact of the Optimus-TMN merger on consumer's surplus, producer's surplus, and welfare in Portugal.

We use Marshallian rather than Hicksian measures of consumer's welfare change. In using the former approach, we also follow the theoretical merger literature assumption of no income effects (Salant *et al*., 1983; Farrell and Shapiro, 1990; Levin, 1990), consistent with Marshallian applied welfare analysis.

While Hicks' compensating and equivalent variations are the correct theoretical measures of the impact on consumer's welfare from a change in a single good's price, most analyses have estimated consumer's welfare change using the Marshallian demand function and consumer's surplus concept. Moreover, prior literature (Willig, 1976) has shown that, if the income effects are small relative to overall income, then the Marshallian consumer's surplus approach provides a sufficiently accurate estimate of the correct compensating and equivalent variations. Hausman (1981), however, points out that the Marshallian approach, despite providing an accurate estimate of the change in consumer's welfare, may result in significant differences in the estimate of the deadweight welfare loss.

Since the total consumer's surplus change, as we shall argue below, represents less than 0.1% of Portugal's GDP, income effects can be considered as being very small relative to overall consumer's income. Thus, the income effects associated with a rise in the average price can be neglected. Moreover, as we shall show below, the deadweight welfare losses are quite small relative to the overall merger impact and to the consumer's surplus change. Thus, the Marshallian consumer's surplus approach used in this paper provides a sufficiently accurate estimate of the impact that the merger would have had on consumer welfare.

Figure 1 represents the welfare impact of the merger, where D is the Marshallian market demand curve, Q is the industry output, total industry voice traffic in minutes, P is the average market price of a minute of voice traffic, c is the industry average marginal cost per minute of voice traffic, and the subscript 0 (1) is for the industry output, price, and marginal cost before (after) the merger.

- Figure 1 about here -

The impact of the merger on consumer's surplus ΔCS, producer's surplus ΔPS, and welfare ΔW is defined and estimated below.

The change in consumer's surplus would have been brought about by the increase in the post-merger average price. The impact of the merger on Marshallian consumer's surplus ΔCS is given by:

$$(5) \qquad \Delta CS = \int_{P_0}^{P_1} Q(P)dP = \int_{P_0}^{P_1} AP^{-\varepsilon}dP = \left[\frac{AP^{1-\varepsilon}}{1-\varepsilon}\right]_{P_0}^{P_1}$$

and corresponds to the area to the left of the demand curve when the average industry price rises from P_0 to P_1 (see also Figure 1).

Substituting in equation (5) the values of parameter A, price elasticity of demand ε, and pre- and post-merger average prices estimated in Sections 3 and 4, the total change in consumer's surplus is €103.9mn per year, which, using a 5% discount rate and an infinite time horizon, has a present value of €2.1bn. Thus, the merger would have had a large detrimental effect on consumer's surplus.

Most of the loss in consumer's surplus, or €99.5mn per year, would have been the result of a surplus transfer from consumers to producers (STCP in Figure 1), since consumers would have paid higher prices at the final, lower level of industry output. The remainder, €4.4mn per year, is a loss of consumer's surplus related to the output that is no longer consumed at the higher price, the deadweight welfare loss (DWL in Figure 1). This means the deadweight welfare loss would have been relatively small compared to the transfer of surplus from consumers to producers or when compared to the overall industry size.

Due to increased market concentration and economies of scale, it is reasonable to expect that the merger would have resulted in an increase of the producer's surplus. The issue is the extent to which the change in the producer's surplus is obtained through increased market power (improved ability to set higher prices) vs. improvements in efficiency (reductions in marginal costs).

Formally, the change in producer's surplus ΔPS is given by (see also Figure 1):

(6) $$\Delta PS = STCP + PEG - LPS$$

where $STCP = (P_1 - P_0)Q_1$, $PEG = (c_0 - c_1)Q_1$ and $LPS = (P_0 - c_0)(Q_0 - Q_1)$. The areas STCP, PEG and LPS are, respectively, the surplus transferred from consumers to producers, the total producer efficiency gain at the final level of industry output, Q_1, and the loss of producer's surplus from the reduction in the level of industry output from Q_0 to Q_1.

Using results from Sections 3 and 4, equation (6) indicates that the producer's surplus would have increased by a total of €267.2mn per year, of which 37.2% would have been the result of a surplus transfer from consumers to producers. Producers would have captured the entire efficiency gain and some surplus from consumers by raising prices. Using the 5% discount rate, the present value of the total producer's surplus increase is €5.3bn.[10]

Finally, the change in welfare ΔW is the result of the change in consumer's surplus and the change in producer's surplus, and is given by the following expression:

(7) $$\Delta W = \Delta CS + \Delta PS$$

In sum, the Optimus-TMN merger would have been welfare-improving by €163.3mn per year, with a present value of €3.3bn. However, the consumer's surplus loss constitutes more than one third of the estimated producer's surplus change and nearly two thirds of the overall welfare improvement.

This result seems consistent with the recent anecdotal evidence of growing industry consolidation. The Optimus-TMN merger case suggests that further industry consolidation is likely explained on both market power and efficiency grounds. Mobile operators merge not only because they have an incentive to increase their market power, but foremost because there are substantial efficiency gains to be had.

6. Caveats

There are a number of issues with the analysis, which we briefly discuss in this Section. First, there is the issue of extending the results of our 45-country sample to the Portugal case. Our estimates are based on approximately 1700 observations which are used to draw inferences relative to the Portuguese market. As mentioned in Section 3, we use international data since our dataset only contains full data for two of the three existing firms in Portugal, Vodafone and TMN.

Other evidence broadly supports the results obtained with the full-sample data. For example, the margin and price regression coefficient estimates for the Eurozone sub-sample and for the OECD sub-sample, both of which include Portugal, are larger than those of the international sample, and the price equation coefficient estimate is approximately twice as large. Moreover, price data for Portugal indicate that, from 1999 to 2004, prices in Portugal fell by less than in other Eurozone countries, suggesting that the level of competition in Portugal was less intense than in other Eurozone countries. Thus, it may be the case that the

Portuguese sub-sample distribution bears more close resemblance to the Eurozone and OECD distributions than to the international one. Therefore, the inferences we make on the rise of prices in Portugal and, consequently, on the surplus redistribution effects from consumers to producers may be, if anything, under-estimated. Indeed, the previously cited result of Grzybowski and Pereira (2007), who estimate an average price increase of 5.7% to 7.1% following the TMN-Optimus merger, points in the same direction.

Second, our SCPP-type comparative statics model departs from the hypothesis that the market is in a long-run equilibrium. The inferences one can draw are also about the long-run equilibrium, after a transitional period, *ceteris paribus*. While there are a number of issues with such models, the fact is that they provide a useful benchmark and have been widely used for merger analysis in the past (Salant *et al*., 1983; Farrell and Shapiro, 1990; Levin, 1990).

Third, as usual in applied work, the analysis faces data constraints. The choice of the price measure is always a difficult issue in telecommunications studies as tariffs are non-linear, with a high degree of price discrimination, and because of large differences across countries. Several studies calculate a price index based on low, average, and high types of consumption bundles. For example, Parker and Röller (1997) use the price of the average consumption bundle, while indicating that they obtain robust results using different consumption bundles. Instead, our dataset's available measure of price is the average revenue per minute. Although there is some loss of information by using an average, this measure has an advantage relative to the use of consumption bundles. Specifically, the average revenue per minute reflects what consumers actually pay, rather than what they might have paid for a hypothetical bundle based on menu tariffs.

It may also be the case that our measure of price-cost margins, the EBITDA margin, captures not only price-cost margins but also efficiencies that reduce fixed costs, such as consolidation of duplicated network installations. If this were the case, our inference about the reduction in the average industry marginal cost might be over-estimated.

In addition, there are 184 observations with negative EBITDA in the sample, a few of which were negative and very large in absolute terms. These observations mean that there are operators for which losses are very large relative to revenues, which suggests that, for these firms, prices are below marginal costs. Our results are robust to the elimination of all these observations, although the coefficient estimates are lower in magnitude. We feel it is appropriate to include the negative EBITDA observations in the sample because they reflect industry dynamics, whereby recent entrants initially have “poor” performance but go on to acquire market share and achieve “normal” performance.

For example, the firms with the most negative EBITDA (-9.17 for Base in Belgium and -8.0 for Amena in Spain, both in 1Q99) were recent entrants in the first quarter of 1999. They went on to gain a significant number of subscribers, a significant market share and attained large and positive EBITDAs afterwards (in 2004). We think this is a fairly normal story and that we are thus well grounded in keeping these observations in the sample.

Moreover, our model does not directly take into network effects, which are likely to play an important role in the telecommunications industry. This happens because our dataset does not contain data which could be used to model switching costs and network effects. However, Pereira and Ribeiro (2007) control for network effects when they estimate demand own-price and cross-price elasticities. Thus, network effects are implicitly reflected into the elasticity estimates we use to simulate the merger. Nevertheless, it is worth stressing that Pereira and Ribeiro find no evidence of significant network effects for the three Portuguese mobile operators.

Our dataset also lacked the most recent data. Hence, we based the analysis on non-weighted 2004 averages from our original data sample, and 2004 industry output data from ICP-ANACOM (2005a), though the merger would have only occurred in 2007, and it would have taken some time to actually merge the operations of the two firms. Not only would prices, margins, and output data have changed somewhat in this period, but the industry as a whole might have also evolved.[11]

Furthermore, we define output as minutes of outgoing calls plus off-net incoming calls, consistent with the way the output is defined in our dataset. However, while the operator revenues derived from outgoing calls are based on retail tariffs, operator revenues for off-net incoming calls (e.g., from fixed networks) are typically based on wholesale tariffs between operators. End consumers pay a higher retail tariff for off-net incoming calls, for which we lack data. Nonetheless, again, we do not expect this issue to affect the order of greatness of the results, nor their implications for policy making. Indeed, if we correct for the difference in off-net incoming call prices (ICP-ANACOM, 2005b), the estimated price of outgoing calls would be €0.201 per minute, which is fairly similar to the average price used in our analysis (€0.197). On the other hand, outgoing traffic was approximately 73.5% of total traffic (10653 million minutes).[12] Thus, roughly 73.5% of the estimated change in consumer's surplus results from the expected change in retail outgoing-call prices.

Fourth, our analysis is robust to changes in the price elasticity of demand. For example, if the average price elasticity of demand were similar to that estimated by Hausman (1997) for the U.S. mobile telecommunications market (0.4), consumer's surplus would have decreased by €107.7mn annually, rather than by €103.9mn (3.7% higher impact), the deadweight welfare loss would have been 81.7% smaller, at €0.8mn annually, and the producer's surplus change would have been 35.2% larger, at €361.4mn annually. Therefore, the qualitative results are the same and the policy implications, discussed further below, do not change.

Moreover, earlier literature has found evidence of collusion in duopoly markets, which may not be well captured by our empirical analysis since our sample contains few duopoly markets. For example, Parker and Röller (1997) find evidence of collusion under a duopoly for U.S. metropolitan areas, with estimated price-cost margins of 35% implying that prices are 23% higher due to collusion. Busse (2000), using the same dataset, estimates that, under duopoly, multimarket contact results in 7% higher prices through collusion. Valetti (1998) as well as Stoetzer and Tewes (1996) argue that the price evolution, before and after the introduction of additional competition in the United Kingdom and in Germany, suggests that there was collusion under duopoly. Hence, this literature suggests that the negative effects of the TMN-Optimus merger on consumer's surplus might have been even larger than argued so far, if (post-merger) collusive behavior were to occur.

Finally, we are not able to control for tax policy effects. In fact, since the Sonaecom-PT merger structure was based on a large level of debt financing, it would have resulted in a reduction of taxable income for the acquired firm, and therefore it would have resulted in a large surplus transfer from taxpayers to producers.

7. Reviewing the PCA decision

In this Section we analyze the aspects of the PCA decision to authorize the Sonaecom-PT merger related to the voice-mobile communications market, and evaluate the decision in the light of the results of our analysis.

In its decision to authorize the Sonaecom-PT merger (Autoridade da Concorrencia, 2006a), the PCA refers that it estimated a +6% effect of the Optimus-TMN merger on prices. In addition, it considered that the efficiency gains claimed by Optimus would not have been sufficient to prevent a rise in prices from the merger, the creation of a merged firm with dominant position, and impediments to effective competition. Thus, it imposed a number of remedies for the relevant markets, including a price cap and seven non-price remedies for the mobile telecommunications market. With these remedies, still according to the PCA, the merger would not have resulted in the creation of a firm with dominant position nor in impediments to effective competition.

The PCA price-cap remedy constrained the merged Optimus-TMN operator to adjust the rate of change of the price for three reference consumption baskets at the lowest of two indicators (Autoridade da Concorrência, 2006a): 1) the rate of change of the price for the same three reference consumption baskets sold by a confidential group of European mobile telecommunications operators; or 2) the rate of change of the consumer price index for services (CPI-S). This price-cap remedy would have expired after a confidential period of time. Its strength would have depended on several factors, for which information was confidential. As such, it is not possible for us to assess the effect of the PCA price-cap remedy objectively.

We have some indirect assessment of the strength of the PCA price-cap remedies through ICP-ANACOM. In its October 19th, 2006 expert opinion on the merger, the ICP-ANACOM criticized the PCA price-cap remedies as insufficient and recommended the implementation of stricter retail price caps (Autoridade da Concorrência, 2006a). In particular, the ICP-ANACOM claimed the discretionary ability to request adjustments in retail price, as well as a negative offset of the CPI-S in 2). Moreover, ICP-ANACOM criticized the fact that, in the PCA's decision, the price-cap revisions 1) or 2) would have had to be initiated by the interested party (Sonaecom), rather than by the regulator. Nonetheless, most of the ICP-ANACOM recommendations on price-cap remedies were not adopted by the PCA in its final decision.

All but two of the seven non-price remedies imposed in the PCA decision (Autoridade da Concorrência, 2006a; Autoridade da Concorrência, 2006b), sought to improve market contestability, by seeking to reduce sunk, fixed, and marginal costs faced by a potential entrant. For example, the remedies a) allowed potential entrants to use Sonaecom base stations (co-location); b) defined favored access tariffs to Sonaecom's networks for potential entrants so as to diminish the network effects of Sonaecom; c) obliged Sonaecom to sign access contracts with virtual mobile network operators (VMNOs) that chose to enter the market. In addition, the PCA required that either Sonaecom or PT's radio frequency rights be returned to ICP-ANACOM. Like the price-remedy case, with the available data, we are unable to further elaborate on the efficacy of the PCA's non-price remedies.

In evaluating the PCA's decision not to oppose a Sonaecom-PT merger and, therefore, a Optimus-TMN merger, it is helpful to recap the main results of our analysis. As discussed above, if the Optimus-TMN merger would have taken place, the average profit margin in the Portuguese mobile telecommunications market would have increased by 11.6 percentage points and the average price would have increased by 3.8%. As a consequence, the average marginal cost would have decreased by 14.9%, and welfare would have increased by €163.3mn per year, a gain entirely captured by the producers. Importantly, the merger would have resulted in a surplus transfer from consumers to producers of €99.5mn per year, or nearly two thirds of the overall welfare improvement.

These findings raise important issues for a social decision-maker on the trade-off between consumer's surplus and social welfare maximization. In particular, the results suggest that the standalone Optimus-TMN merger could have been authorized on efficiency and welfare maximization grounds. However, merger remedies would have been required, in order to ameliorate the large detrimental impact of the merger on consumer's surplus.

Specifically, we calculate the present value of the consumer-surplus loss at €2.1bn. Consequently, merger remedies should have been designed to address this loss directly. A price-cap remedy, based on the average revenue per minute, would have been an appropriate instrument to achieve this objective. Importantly, a price-cap merger remedy would have been welfare enhancing, compared to a merger without remedies, because total welfare would have increased by $\mathrm{DWL} + \mathrm{LPS} + \mathrm{APEG}$, where APEG represents the additional producer efficiency gain due to the price-cap remedy (see Figure 1).

In summary, our results can be construed as supporting the PCA decision to allow the Optimus-TMN merger within the context of the authorization of the Sonaecom-PT merger. However, it is not possible to assess whether the PCA decision remedies would have been sufficient to avoid the loss in the consumer's surplus that the Optimus-TMN merger would have induced.

8. Conclusions

This paper uses an international sample of 177 mobile operators in 45 countries between 1Q99 and 2Q04 to evaluate the extent to which further industry concentration is driven by market power or efficiency gains. To do so, it develops a novel merger simulation methodology based on the pre- and post-merger change in the performance of a hypothetical firm with average market share. Unlike the now near-standard Baker-Bresnahan approach that assumes a given variation of marginal costs, the methodology proposed here allows the simulation of the effect of a merger on both prices and marginal costs, and the estimation of industry welfare effects. In addition, it avoids the potential bias introduced by incorrect post-merger estimates of HHI used in other merger simulation methodologies, since the post-merger average market share is known with certainty, whereas post-merger HHI is not. Finally, it has much lower data and computational requirements. These advantages have to be balanced against the loss of information that results from the use of averages in our methodology. In sum, we believe that the merger simulation methodology proposed here is a complementary approach that contributes to a more robust decision making process in merger review and appraisal.

We apply the methodology to the voice-communications market within the context of the proposed Sonaecom-PT merger, which was authorized by the PCA on the basis of the analysis of 46 relevant markets, but which in the end failed to get stockholder approval for a change to PT's shareholder bylaws. We find large consumer's surplus losses and large producer's surplus gains. Nonetheless, we find that the merger would have been welfare enhancing and argue that price-cap regulation would have been warranted. The analysis can be broadly construed as supporting the PCA decision to authorize the merger with respect to this market, on efficiency grounds.

Our results have the following policy implications. First, they offer part support, on efficiency grounds, of past policy makers decisions to authorize further consolidation in this industry. However, we also find that further consolidation should be accompanied by price-cap regulation since it results in consumer's surplus losses. In fact, our analysis of the Optimus-TMN merger case suggests that price-cap regulation would be welfare enhancing relative to a situation where the merger is authorized but no price caps are imposed.

The finding that industry consolidation is welfare enhancing might bring into question the current regulatory approach towards the mobile telecommunications sector. In particular, it suggests that the relatively "hands-off" approach to retail price regulation in this sector may not be feasible going forward. Per definition, it is not possible to rely on competition to ensure market performance while at the same time allowing further industry consolidation. This suggests retail price regulation may be required. Alternatively, it might suggest that regulators might need to consider balancing the trade-off between efficiency and the degree of competition in the industry. If so, further research of the underlying rationale is required.

Finally, this paper, particularly when considered in combination with Gryzbowski and Pereira (2007), which equally focused on the Optimus-TMN merger, offers pointed evidence on the important role of the "efficiency defense" clause in the regulatory review process of merger proposals (Williamson, 1968). It points out that the Baker-Bresnahan merger simulation methodology, which assumes a given change in marginal costs, may under-estimate potential efficiency gains and therefore be biased towards the rejection of mergers.

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Table 1. Price equation

Dependent variable: logarithm of average revenue per minute calculated using (1) 2004 nominal exchange rates to the Euro; (2) data in Euros; (3) annual PPPs to the US Dollar.

	(1)	(2)	(3)
	Full sample	Eurozone sample	OECD Sample
Lagged market share	0.229	0.459	0.413
	(0.000)	(0.000)	(0.000)
Lagged churn rate	-1.133	0.603	-6.764
	(0.203)	(0.602)	(0.000)
Mobile party pay	-0.527		-1.830
	(0.000)		(0.000)
Observations	1658	457	1141
R-squared	0.874	0.827	0.792

P-values based on robust standard errors are in parentheses. Regression controls include country, year and quarter effects. Country and year effects are jointly significant at 1% level. Quarter effects are jointly significant at 1% level in (1) and at 10% level in (2). They are not jointly significant in (3).

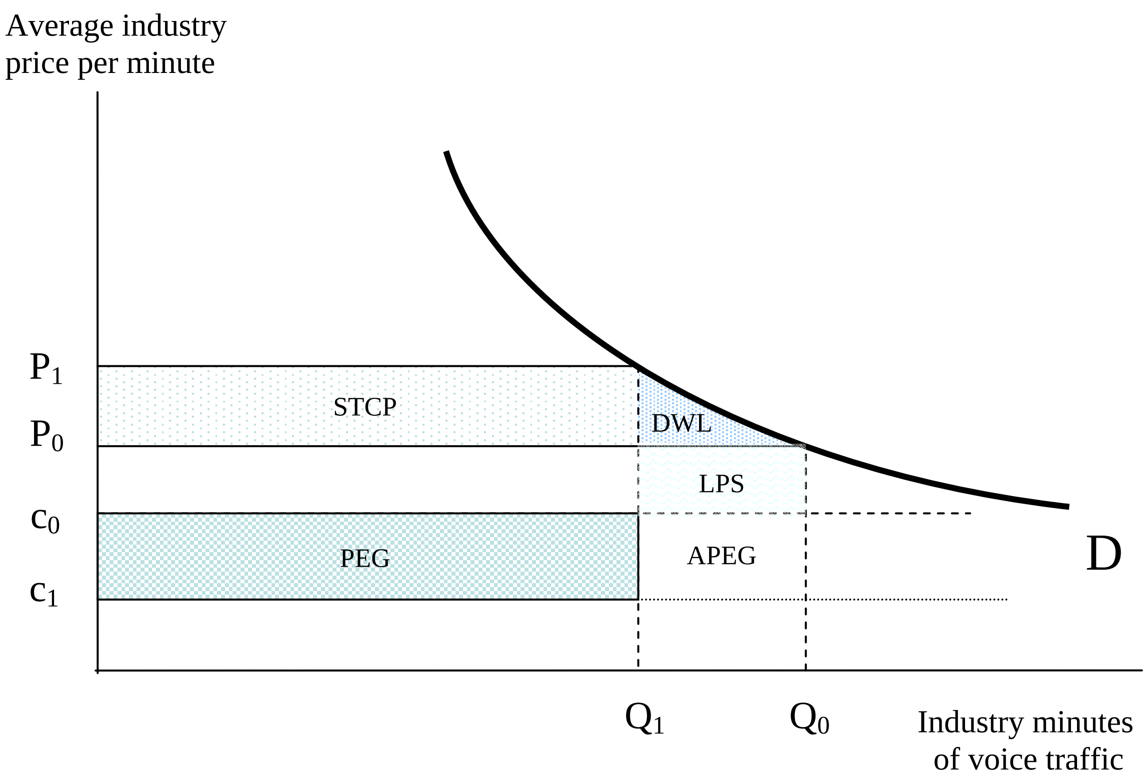
Table 2. Price-cost margin equation

Dependent variable: EBITDA margin

	(1)	(2)	(3)
	Full sample	Eurozone sample	OECD sample
Lagged market share	0.696	1.080	0.742
	(0.000)	(0.000)	(0.000)
Lagged churn rate	-0.131	0.430	-0.773
	(0.535)	(0.800)	(0.401)
Observations	1846	468	1168
R-squared	0.560	0.667	0.526

P-values based on robust standard errors are in parentheses. Regression controls include country, year and quarter effects. Country and year effects are jointly significant at 1% level. Quarter effects are not jointly significant.

Figure 1. Welfare effects



Appendix A. Selected sample statistics

Table A1. Variables

Variable	Obs	Mean	Std Dev	Min	Max
EBITDA	2482	0.269	0.375	-9.170	0.770
MSHARE	3390	0.284	0.176	0.010	0.950
MPP	3760	0.163	0.369	0.000	1.000
CHURN	2074	0.022	0.017	0.001	0.400
ARPM	2107	0.184	0.093	0.026	1.065

Table A2. Correlation matrix

	EBITDA	MSHARE	MPP	CHURN	ARPM
EBITDA	1.000				
MSHARE	0.550	1.000			
MPP	-0.167	-0.308	1.000		
CHURN	-0.081	-0.230	0.145	1.000	
ARPM	-0.077	0.091	-0.178	-0.440	1.000

Table A3. Year effects

Year	Freq	Perc	Cum
1999	656	18.37	18.37
2000	634	17.75	36.11
2001	630	17.64	53.75
2002	653	18.28	72.03
2003	663	18.56	90.59
2004	336	9.41	100.00

Table A4. Quarter effects

Quarter	Freq	Perc	Cum
1	976	27.32	27.32
2	979	27.41	54.73
3	810	22.68	77.41
4	807	22.59	100.00

Table A5. Country effects

Argentina, Australia, Austria, Brazil, Belgium, Canada, Check Republic, Chile, China, Colombia, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States, Venezuela.

Appendix B. Methods

This Appendix explains why we use simple OLS estimates as a basis for our merger analysis. Let us consider the panel-data model:

(B1) $Y_{it} = \gamma_i + \gamma W_{it-1} + e_{it}$ with $t = 1,...,T$ and $i = 1,...,N$

where Y_{it} is either price or price-cost margin, γ_i captures firm-specific effects, W_{it} is a set of time-varying explanatory variables, such as market share and churn rate in our framework, and e_{it} represents residuals, assumed to be serially uncorrelated and interpretable as unexplained shocks to the dependent variable.

When γ_i is disregarded (i.e. not included in model (B1)), the OLS estimator is consistent if $E[W_{it-1}e_{it}] = 0$. Since there is no *contemporaneous* interaction between W_{it-1} and e_{it}, this assumption can be made. Indeed, we can argue that the market share (churn rate) of firm i at time $t-1$ is not affected by a price (price-cost margin) shock which happens at time t (this is why we use W_{it-1} rather than W_{it}). Instead, when γ_i is not disregarded, the OLS estimator is consistent if $E[W_{it-1}(\gamma_i + e_{it})] = 0$. However, in this case, there is no reason to believe that the latter condition holds because there is no reason to assume $E[W_{it-1}\gamma_i] = 0$. Indeed, we cannot argue that the market share (churn rate) of firm i at time $t-1$ is uncorrelated with time-invariant unobserved characteristics of firm i. Therefore, we need to explore alternative estimators that explicitly take γ_i into account. In what follows, we briefly review the available alternatives: the Between Effects estimator (BE), the Fixed Effects estimator (FE), the Random Effects estimator (RE), and the First Differences estimator (FD).

If we take averages over time, we can write model (B1) as:

(B2) $\overline{Y}_i = \gamma_i + \gamma \overline{W}_{i,-1} + \overline{e}_i$

where $\overline{W}_{i,-1} = \frac{\sum_{t=2}^{T} W_{it-1}}{T-1}$, $\overline{Y}_i = \frac{\sum_{t=1}^{T} Y_{it}}{T}$ and $\overline{e}_i = \frac{\sum_{t=1}^{T} e_{it}}{T}$.

Given the nature of our explanatory variables, we must assume that they are not strictly exogenous, i.e. $E[\overline{W}_{i,-1}\overline{e}_i] \neq 0$, $E[\overline{W}_{i,-1}e_{it}] \neq 0$ and $E[W_{it-1}\overline{e}_i] \neq 0$, and that they can be contemporaneously correlated with the residuals[13], i.e. $E[W_{it}e_{it}] \neq 0$ or $E[W_{it-1}e_{it-1}] \neq 0$.

The BE estimator is the OLS estimator applied to model (B2) and is consistent if $E[\overline{W}_{i,-1}(\gamma_i + \overline{e}_i)] = 0$. However, likewise the simple OLS case, there is no reason to believe that this orthogonality condition holds because there is no reason to assume $E[\overline{W}_{i,-1}\gamma_i] = 0$ and because $E[\overline{W}_{i,-1}\overline{e}_i] = 0$ is not satisfied.

The FE estimator is the OLS estimator applied to the following transformed model (within-transformation):

(B3) $Y_{it} - \overline{Y}_i = \gamma(W_{it-1} - \overline{W}_{i,-1}) + (e_{it} - \overline{e}_i)$

It is consistent if $E[(W_{it-1} - \overline{W}_{i,-1})(e_{it} - \overline{e}_i)] = 0$. However, like the previous case, there is no reason to believe that this orthogonality condition holds because $E[\overline{W}_{i,-1}\overline{e}_i] = 0$ and $E[\overline{W}_{i,-1}e_{it}] = 0$ are not satisfied.

The RE estimator is an efficient GLS estimator combining the information from the between and the within dimensions of the data in an efficient way. It is consistent if the assumptions for both BE and FE hold. However, again, there is no reason to make these hypotheses.

A further alternative is the FD estimator, which is the OLS estimator applied to the following transformed model (first-differences transformation):

$$\text{(B4)}\ \ Y_t - Y_{it-1} = \gamma(W_{it-1} - W_{it-2}) + (e_{it} - e_{it-1})$$

where $Y_{it-1} = \gamma_i + \gamma W_{it-2} + e_{it-1}$

It is consistent if $E[(W_{it-1} - W_{it-2})(e_{it} - e_{it-1})] = 0$. However, even in this case, there is no reason to believe that the latter condition holds because $E[W_{it-1}e_{it-1}] \neq 0$.

Hence, all the panel-data estimators described so far are inconsistent unless we make use of instrumental-variable techniques. However, the implementation of instrumental-variable techniques is only possible if instrumental variables are available. If we do not have external instruments but we have panel data (i.e. our case), we can (only) use internal instruments in order to perform consistent estimation. For instance, W_{it-2} ($MSHARE_{icyq-2}$ and $CHURN_{icyq-2}$ in our framework) can be used as instrument for $(W_{it-1} - W_{it-2})$ because W_{it-2} is correlated with $(W_{it-1} - W_{it-2})$ but is orthogonal to $(e_{it} - e_{it-1})$. Therefore we can use the Instrumental Variable First Differences estimator (IVFD).

Note that, when considering the within-transformation rather than first-differences transformation, we cannot use internal instruments. To be more explicit, following the previous example, W_{it-2} cannot be used as instrument because it is may be correlated with $(W_{it-1} - \overline{W}_{i,-1})$ but there is no reason to assume that it is orthogonal to $(e_{it} - \overline{e}_i)$ because there is no reason to assume $E[W_{it-2}\overline{e}_i] = 0$ (note that $E[W_{it-2}e_{it-2}] \neq 0$). So, the IVFE approach is unavailable.

Analogously, the IVBE approach is unavailable because there is no reason to assume $E[W_{it-2}(\alpha_i + \overline{e}_i)] = 0$. By consequence, the IVRE approach, based on the assumptions of both

IVBE and IVFE, is unavailable too. So, the IVFD estimator is the only estimator that is consistent when model (B1) is taken as underlying model, among those (for static panel-data models) explored in this Appendix.

Unfortunately, as we shall see below, the IVFD estimator provides very imprecise estimates with large standard errors[14] and confidence intervals, and the estimates themselves are not necessarily reliable because the instruments' performance is not optimal[15]. So, we should see IVFD estimates basically as an indication of the sign of γ rather than as an indication of the absolute magnitude of the coefficient.

Table B1 and Table B2 present price and price-cost margin estimates of lagged market share and lagged churn rate based on all the estimators described so far, using the full ML sample. In what follows, we focus on the market-share coefficients since these estimates are used in our merger analysis.

The results for the price regression in Table B1 are not very stable. The IVFD estimator, the only one that is consistent by construction[16], provides the indication of a positive market-share coefficient (note that we should not rely very much on the magnitude of this coefficient because the 95% confidence interval is very large: it goes from the negative value -1.245 to the positive value 2.046[17]). The only two alternative estimators that provides positive estimates are the BE estimator and the OLS estimator. Between these two, we prefer to choose the OLS estimator because the BE estimator is likely to be more biased than the OLS estimator as it requires stricter orthogonality conditions to hold than the OLS estimator (for details, see the discussion above).

Also note that the negative impact of the market share on price, estimated by FE, RE and FD, is unappealing from an economic-theory point of view. Unless we completely reject the market-power hypothesis, it is unreasonable to think that the market share of a firm has a negative causal impact on the ability of the firm to set higher prices.

The estimates for the price-cost margin regression in Table B2 are quite stable and there is no issue of results sensitive to the estimation technique. The IVFD estimator provides again the indication of a positive market-share coefficient (again note that we should not rely very much on the magnitude of the coefficient because the 95% confidence interval is very large: it goes from 0.193 to 3.162[18]). For comparability reasons, due to the results of the price regression and the choice of the OLS estimate as proxy of the impact of the market share on the price level, we choose the OLS estimate as proxy of the impact of the market share on the price-cost margin.

Table B1. Price equation

Dependent variable: logarithm of average revenue per minute calculated using 2004 nominal exchange rates to the Euro (Full sample)

	OLS	BE	RE	FE	FD	IVFD
Lagged market share	0.229	0.411	-0.248	-0.603	-0.112	0.401
	(0.000)	(0.009)	(0.001)	(0.000)	(0.587)	(0.633)
Lagged churn rate	-1.133	2.824	-2.259	-2.328	0.193	0.050
	(0.203)	(0.447)	(0.000)	(0.000)	(0.737)	(0.984)
Mobile party pay	-0.527	-2.534	-2.311			
	(0.000)	(0.000)	(0.000)			
Observations	1658	1658	1658	1658	1551	1551
F-statistics *						
Market share equation						32.04
Churn rate equation						3.88

* Test of joint significance of instrumental variables in first-stage regressions
P-values in parentheses are based on robust standard errors

Table B2. Price-cost margin equation

Dependent variable: EBITDA margin (Full sample)

	OLS	BE	RE	FE	FD	IVFD
Lagged market share	0.696	0.507	0.719	0.694	0.512	1.678
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.027)
Lagged churn rate	-0.131	-2.033	0.343	0.395	0.673	0.107
	(0.535)	(0.173)	(0.067)	(0.036)	(0.000)	(0.845)
Observations	1846	1846	1846	1846	1731	1731
F-statistics *						
Market share equation						37.71
Churn rate equation						1.46

* Test of joint significance of instrumental variables in first-stage regressions
P-values in parentheses are based on robust standard errors

Endnotes

[1] Indeed, mergers and acquisitions have been a feature of the mobile telecommunications industry, particularly since the beginning of this decade. For example, in the US, the industry was already "highly concentrated" according to the Department of Justice Merger Guidelines (HHI of 1800), even before the Cingular-AT&T Wireless and the Sprint-Nextel mergers in 2004 and 2005, which took the HHI in the average US market first from 2900 to 3100, and then to 3300 (based on pre-merger market shares). This implies that there are now the equivalent to three equal sized operators in the average US market (Bajari *et al*, 2008). In fact, Fox (2005) argued that the U.S. mobile telecommunications industry was more concentrated in 2005 (HHI of 6000 based on radio-spectrum licenses) than in 1998, when the industry was characterized by a duopoly.

Other developed countries have also experienced growing consolidation. In Austria, the number of operators fell from 5 to 4 and the HHI rose from 2880 to 3430, following the acquisition of Tele.ring by T-Mobile Austria in 2005. In the UK in 2009, the T-Mobile UK and Orange UK merger proposal, with the stated aim of attaining cost efficiencies, would reduce the number of the main mobile network operators from 4 to 3, with the HHI rising from approximately 2300 to 3200 (based on pre-merger market shares).

[2] The decision was based on the analysis of the effect of the merger on 46 relevant markets, but this paper focuses only on the impact that the Optimus-TMN merger would have had on the performance of the Portuguese mobile-voice communications market. Mobile-voice communications represented approximately 80% of the €3bn mobile telecommunications industry, or approximately 33% of the overall €7.3bn electronic telecommunications industry in Portugal in 2004.

[3] Baker and Bresnahan (1985) were the first to propose the methodology for the evaluation of mergers in differentiated product industries, though other authors have since then made significant contributions to the methodology.

The Baker-Bresnahan merger simulation methodology first requires the estimation of firm demand own-price and cross-price elasticities for the firms involved in the merger. Pre-merger prices, which are known, and the estimated demand elasticities, are then substituted in a system of profit-maximization equations to determine pre-merger marginal costs. Assuming post-merger marginal costs do not change, the post-merger system of profit-maximization equations is then used to infer post-merger prices. Thus, the effect of the merger on prices can be estimated. In this approach, merger efficiency gains are simulated through sensitivity analysis, by reducing post-merger marginal costs in ad-hoc manner.

[4] Note that dissatisfaction with the use of concentration measures in product-differentiated markets led to the development of the Baker-Bresnahan merger simulation methodology, which eschews the use of such measures. See also footnote 3.

[5] Stewart and Kim (1993) estimate the effect of exogenous factors and a merger activity-level index on price indices change and price-cost margins indices change, for a cross-sectional sample of 117 U.S. three digit manufacturing industries for 1985-86. Their aim is to calculate the impact of the merger activity-level on consumer's surplus, producer's surplus, and welfare for industries grouped according to concentration levels. They use the estimated impact of merger activity on price and price-cost margin changes to calculate the change in firm profits and consumer's surplus from mergers.

In contrast, we base our estimation on the effect of the merger on the performance of a hypothetical firm with average market share. We estimate the model using actual pre-merger price and price-cost margin levels for a single industry, and then infer what would have happened following a merger. In particular, our approach to infer cost efficiencies and producer's surplus gains is more straightforward than that of Stewart and Kim (1993).

[6] The churn rate measures the fraction of a firm's customers who cancel subscriptions within a given time period. On an annual basis, churn rates of between 18% and 36% are quite common. Customer churning could indicate the presence of intense competition, putting downward pressure on prices and margins. However, higher churning directly increases costs associated with managing and marketing customer accounts, which could put upward pressure on prices.

[7] In the countries where just the calling party pays the cost of a call, traffic is measured as minutes of outgoing calls plus minutes of incoming traffic from other networks (off-net). In the MPP countries (Canada, China, Hong Kong, India, Singapore, United States), traffic additionally includes on-net incoming traffic, which means that on-net traffic is double counted since the same minute of traffic is billed to both calling parties (caller and receiver).

[8] Interestingly, the Financial Times Lex column of October 3rd, 2006 suggested that the merged firm (Optimus-

TMN) could have increased its EBITDA margin to 48%, fairly similar to our own estimate.

[9] The average revenue per minute in 2004, based on ICP-ANACOM (2005a), is €0.169 or 14.2% lower than Merrill Lynch's first half of 2004 data. The difference may be explained by falling prices in the second half of 2004, the use of weighted vs. non-weighted estimates, and measurement discrepancies. To maintain consistency in the use of the econometric results, we use Merrill Lynch estimates.

[10] Private sector firms calculate the present value of the synergies of a merger based on a shorter time horizon (7 years), and often with no discount rate. Using this methodology, we estimate the private value of the merger at €1.9bn. This compares with an estimate of €2bn provided by the Financial Times Lex column of February 21st, 2007.

[11] A seminar participant pointed out that new technologies (e.g. VoIP and Wi-fi) may affect the competitive dynamics in this industry. Nonetheless, the effect of new technologies is likely to remain marginal in the near term. In fact, in mature markets, mobile operators' revenues and output are still growing, even if at lower rates than in the past. Thus, the merger would still have had a large economic impact.

[12] The merger effect on consumer's surplus could have been lessened if the mobile-to-mobile off-net traffic between TMN and Optimus became on-net traffic as a result of the merger. Since off-net tariffs are higher than on-net tariffs, this might have resulted in a smaller increase of the average price than that predicted by our model. Total mobile-to-mobile off-net traffic between the three pre-merger operators was 2147 million minutes or 14.8% of total traffic. However, the PCA (Autoridade da Concorrência, 2006a) did not impose lower on-net call prices between TMN and Optimus subscribers in its decision to allow the merger. Thus, apparently, the merged operator would have had the choice to maintain off-net prices for communications between TMN and Optimus subscribers.

[13] For instance, the market share of a firm at time t can affect the price-cost margin of the firm at time t, but the converse is also true.

[14] This is partly due to the fact that the residuals of model (B4), Δe_{it}, are autocorrelated by construction (note that Δe_{it} is correlated with Δe_{it-1} through e_{it-1}, even if e_{it} is uncorrelated with e_{it-1}). And, in our application, using the Newey-West correction for first-order autocorrelated residuals does not significantly improve precision.

[15] Specifically we find that the instruments W_{it-2} are weak in the (first-stage) churn-rate regression (the F-statistic is lower than 10) while they are good in the market-share regression (the F-statistic is well above 10). And, in our application, using ΔW_{it-2} as alternative or additional instruments does not improve the overall instruments' performance.

[16] It may be inconsistent as well if e_{it} exhibits autocorrelation or in presence of clearly weak instruments (which is not our case).

[17] Using the Newey-West correction, the range goes from -1.058 to 1.860.

[18] Using the Newey-West correction, the range goes from 0.269 to 3.086.