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Prices and Price-Cost Margins of Mobile Voice Services

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Prices and price-cost margins of mobile voice services*

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Abstract

This paper examines the determinants of prices and price-cost margins for an international sample of 177 mobile voice operators in 45 countries over the 1999-2004 period. In markets for mobile voice services, it is likely that firms with large market share have substantial market power and higher prices and price-cost margins than fringe firms do. In fact, our empirical analysis shows that market share has a positive and significant impact on prices and margins, after controlling for market characteristics and country and time effects. However, we find no relationship between market share and prices for firms with large market share. Finally, high price and high margin firms respond more similarly and less pronouncedly to an increase in market share than low price and low margin firms.

JEL classification: L11, L13, L40, L96

Keywords: telecommunications, price setting behavior, market power

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1. Introduction

From 1995 to 2005 the number of mobile voice services subscribers (analog and digital technologies) grew from approximately 91 million to 2 billion. GSM (Global System for Mobile communication) technology has experienced an even faster growth from 12.5 million to 1.7 billion subscribers in the same period. No other consumer technology has seen such a widespread diffusion in such a short time-frame. By the end of 2005 mobile revenues had reached 573 Billion USD, representing more than half of the total for global telecommunications services. By comparison, at the end of 2005 there were 1.2 billion fixed network subscribers worldwide generating revenues of 424 Billion USD.[1] Clearly mobile voice services moved from being a niche product to a major industry in a very short period of time.

While land-based telephone services have long been regulated as natural monopolists, the competitive environment for mobile operators has differed. From the outset, digital mobile telecommunications regulators in the US, Europe, and elsewhere have promoted market structures based on some degree of competition (Busse, 2000; Parker and Röller, 1997; Grzybowski, 2005). Multiple service providers normally compete in markets for mobile services. Markets that were once primarily local have expanded geographically; providers often offer service plans covering areas that are national or international in scope. However, as total output and market sizes have grown, a few large firms have achieved large market shares in many markets. Thus, while growth has been accompanied by competition, that competition is not of an atomistic variety. Competition has featured oligopolistic interaction, differentiation of products, and "winner-take-most" outcomes typical of goods featuring network externalities.

This paper offers an overview of the state of competition in worldwide markets for mobile voice services. We will investigate the dispersion of prices and price-cost margins in

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[1] Sources: GSM World "2006 World Market Report", www.gsmworld.com seen Apr. 20, 2006;

order to assess the nature of competition across markets.

Price comparisons for mobile voice services are problematic due to the multi-dimensionality of usage and non-linearity of mobile services pricing plans. Most comparisons have focused on particular aspects of the pricing plan, for example, considering only local rates (CTIA, 2004) or price per minute in a package (i.e., if all minutes are used up) rather than price per unit of actual usage, or the calculated price for subset (basket) of possible calls (Teligen, 2003; Parker and Röller, 1997; Grzybowski, 2005). In this study we argue that a better measure of the price of mobile telecommunications services is average revenue per minute, one of the indicators used in the FCC's 9th CMRS report (FCC, 2004)[2] and reported in Merrill Lynch's Global Wireless Matrix survey. On the basis of this measure, the differences in the price levels in the data we have gathered is quite large. In 2004, average revenue per minute varied from 0,028 Euro per minute offered by China Unicom to 0,45 Euro per minute offered by Switzerland's Swisscom.[3] Since labor costs represent a small fraction of the operating costs of mobile operators (6,3% and 11,3%, respectively for the above operators, but typically under 10%), and investment costs in infrastructure on a per subscriber basis are similar, the substantial differences in pricing are surprising, even considering differences in usage patterns and differences in the size of the firms.

There are several possible explanations for the observed differences in price levels. In the presence of market power, exogenous demand-side variables, for example income per capita, might result in an equilibrium price level that is higher in some countries than others (see Panzar and Rosse, 1987). Other possible explanations include varying regulatory environments. Most countries require calling party pays (CPP) pricing, but the US,

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and ITU-T, 1999, "World Telecommunications Development Report 1999".

[2] See Paragraphs 168 through 172. Other indicators used by the FCC are the US Bureau of Labor statistics cellular telephone services component of the consumer price index, and Econ One's simulated average cost of monthly service calculated across four typical usage plans.

[3] See discussion in Section 4 for characterization of the unit of output used in this analysis, minute of voice call. China Unicom counts on-net incoming minutes of calls twice. If one corrects for this effect using Merrill Lynch's estimate of the percentage of on-net incoming calls (20%), China Unicom's adjusted revenue per minute is 0,032€.

Canada, China, and some other countries have adopted mobile party pays (MPP)[4] pricing. Country regulations also differ in whether or not they require number portability. Prices could also vary because of cost or quality differences that ultimately result in differences in non-cooperative differentiated oligopoly (endogenous) equilibria, or because firms vary in their success in colluding in different countries. Of course there are other alternative hypotheses that could explain the difference in the levels of average revenue per minute across countries.

Past analyses and academic research have focused on the latter two hypotheses, namely market power and collusion. For example, the US congress has tasked the FCC to annually assess “whether or not there is effective competition” in commercial mobile radio services, but FCC Commissioner Michael J. Copps in the 8th CMRS Report argues that the FCC has been unable to present a definition or for that matter a test of “effective competition”. Collusive behavior has long been considered one of the gravest forms of economic misconduct, and there have been a number of recent findings with regard to potentially collusive mobile telecommunications markets. For example, in a study of mobile telecommunications duopolies in US metropolitan service areas, Parker and Röller find evidence of collusion and of multi-market contact collusion. Using a different methodology considering price plans, Busse (2000) also finds some evidence of multi-market contact collusion in US metropolitan areas for mobile voice services, with prices rising between 7% and 10% above non-cooperative levels. The European telecommunications regulatory agencies have also started inquiries on interconnection fees and roaming charges, and the European Commission has recently recommended that roaming charges be cut to the level of national interconnection charges. Also recently, the French Competition Council has fined

[4] Regulatory aspects and historic legacy may explain some of the difference in pricing between the US and other world markets. For instance in the U.S. and in other countries prefixes are assigned by geographic area for both mobile and fixed network telephones. Traditionally, tariffs were typically based on origin and destination number prefixes, and therefore network operators were unable to charge different prices for fixed network and mobile network services. As a result, when the mobile service was introduced, the US mobile operators required subscribers to pay for incoming calls (Mobile Party Pays), given their own higher marginal costs.

the French mobile operators €534M for what it claimed was a collusive market share agreement.[5]

In the academic literature, assessing the degree of competitiveness or, alternatively, the degree of market power, has often involved measurement of price-cost margins and profitability, rather than analysis of price differences across markets. Inferences about the existence of market power are clouded by two opposing hypotheses (Feuerstein, 2005). One branch of the literature suggests that firms will exploit their market power to extract rents. The Structure Conduct Performance Paradigm (SCPP), implies that market structure characteristics such as industry concentration will predictably lead to differences in conduct and performance, although conduct itself may not be observed (Scherer and Ross, 1990). Since the late 1970s, the "New Empirical Industrial Organization" (NEIO) approach has argued that conduct must be modeled with explicit assumptions on firm behavior and firm conjectures (Bresnahan, 1989). More recently, the market power literature has been enriched by the consideration of the dynamic aspects and strategic interaction between firms (see Feuerstein, 2005 for an overview of the literature).

The second branch of the literature is developed from the efficiency hypothesis, which suggests that higher allocative and technical efficiency will result in firms gaining market share and being more profitable, and the industries being more concentrated (Demsetz, 1973; Bos, 2003; Berger, 1995). Thus, according to this literature, the existence of high price-cost margins may not reflect abuse of market power but may simply result from differences in costs across firms. Given this possibility, empirical findings that associate market shares with higher price cost margins have inconclusive implications about the nature of competitive behavior.

Despite the large literature and empirical analyses, this paper is the first, to our knowledge, to attempt to empirically explain why there is such a wide difference in the level

[5] Adam Jones, Dec. 1, 2005, "French top mobile groups fined", Financial Times, London. See also the French Regulator decision (http://www.arcep.fr/textes/juris/05-d-65.pdf).

of prices for mobile voice services across firms and countries, with a particular focus on the difference of prices across firms in a given country. Our tests are carried out using a dataset containing quarterly data on 177 firms in 45 countries from 1999 through 2004, created from the Merrill Lynch Wireless Global Matrix report.

This paper is organized as follows. Section 2 reviews the literature. Section 3 presents the data. Section 4 develops the theoretical model. Section 5 presents the econometric specification and the econometric results. Section 6 develops an analysis of the Portuguese market and Section 7 concludes. In addition, Appendix 1 defines our measures of revenues, output, price, and profitability.

2. Literature review

Academic researchers and government regulators in this sector have in the past focused on issues of market power (dominance) and collusion. The traditional structure-conduct-performance paradigm (SCPP) argued that while conduct could not be observed, one could infer performance through market structure characteristics (Scherer and Ross, 1990; Bresnahan, 1989). Thus, for example, according to the SCPP, it was expected that a market structure characterized by high levels of industry concentration (measured, for example by the Herfindahl-Hirschman Index (HHI)), would create an environment where conduct based on exercise of market power and collusion would be facilitated, thus resulting in a "deficient" market performance, i.e., high price-cost margins, high producer surplus, and large deadweight welfare losses. The SCPP approach was criticized for the lack of theoretical justification for using market concentration measures to analyze market performance and because market structure measures are endogenous.

The "new empirical industrial organization" (NEIO) research approach seeks to explain firm and industry performance characteristics such as output, price, and profitability, within a structure that is explicitly derived from oligopoly theory. Typically, in the NEIO models (Iwata, 1974; Bresnahan, 1982; Panzar and Rosse, 1987; Jaumandreu and Lorences, 2002), an estimable conduct parameter (or set of parameters), θ, is derived based on firm or oligopoly theory, and the hypothesis of strategic behavior is then tested against the null hypothesis of perfect competition. Although these methods of estimating market power, and in particular Panzar and Rosse's H test (1987), have had widespread use, they have been criticized due to their strong assumptions regarding the functional form of demand and failure to consider the dynamic strategic behavior among firms.

More recent research has focused on conditions for the sustainability of collusion in dynamic strategic behavior games and in the development of tests for collusion in procurement auctions. See Feuerstein (2005), Harrington (2005) and Porter (2005) for a review of the more recent literature on the measurement of market competitiveness.

In this paper, we primarily follow the NEIO tradition, analyzing firm and industry conduct in the context of a Cournot-type model (Appelbaum, 1982; Bos, 2003).

3. Data

The empirical analysis developed in this paper uses a dataset built using Merrill Lynch's Global Wireless Matrix 2Q04 report (hereinafter ML dataset). The Merrill Lynch report contains quarterly data on 177 firms across 45 countries from the first quarter of 1999 to the second quarter of 2004. This dataset includes several variables relevant to the analysis developed in this paper, including revenue per minute, minutes of use, market share, earnings before interest depreciation and amortization (EBITDA) margin, and churn rates.

The summary sample statistics for the ML data-set are reported in Table 1. We eliminated observations where market share or churn rate was zero, since they correspond to instances where the firm had not yet started operating in the year the observation was collected.

Firms in the mobile industry report their financial and operational data in a structure that it is fairly similar, but there are often differences in how the variables are originally defined and reported by firms. For example, operators define subscriber acquisition and retention costs differently and also account for them differently in their financial reports, with some booking these costs upfront and some other operators depreciating costs over a period of time. Operators also employ different definitions of minutes of use, with some considering only outgoing minutes of voice calls, others considering both incoming and outgoing, and yet others subtracting a part of the incoming minutes of calls to avoid double counting of on-net mobile to mobile minutes of calls. The number of subscribers and therefore the churn rate is also subject to different definitions, as operators grant subscribers different grace periods before canceling subscriptions. Merrill Lynch compiles the Global Wireless Matrix based on company-reported numbers, and attempts to incorporate adjustments to standardize the variables across companies to the extent possible. Appendix 1 provides a characterization of our measures of revenue, output, price, and profit.

4. Theoretical Analysis

We seek to identify factors affecting the mean and the shape of the conditional distribution of prices and price-cost margins in mobile voice telecommunications services. Specifically, the empirical specification of our price-cost margin equation is derived from a Cournot-type differentiated oligopoly model similar to those of Appelbaum (1982), Parker and Röller (1997), and Bos (2003). Our price equation specification has the same set of independent variables as the margin equation. If prices and margins are responsive in similar fashion to the same variables, this would suggest that much of the variation in margins is price-driven.

4.1. A Cournot-type differentiated oligopoly model

Assume the unit of output is the same representative minute of outgoing mobile voice call, but output is perceived as having different quality across firms. Assume further that each firm's demand function depends only on total output, i.e., $p_i(Q) = p_i\left(Q = \sum_{j=1}^{n} q_j\right)$, but that the demand function varies across firms, i.e., the equilibrium prices per unit of output across firms in a given market need not be the same thus allowing for different levels of prices for output perceived as being of different quality varieties across firms. Thus, each firm maximizes:

$$\pi_i = p_i(Q) \cdot q_i - CT_i(q_i) \quad , \quad Q = \sum_{j=1}^{n} q_j$$

where Q is total (quality unadjusted) industry output (minutes of voice calls) in a given market, defined as being the sum of each individual firm's output, p_i, is the price for firm *i*'s minute of representative voice calls, which depends on total output. Further, like Bos (2003) we assume constant marginal costs. Assuming a differentiated oligopoly, i.e., each firm in equilibrium sells its unit of output for a different price, each firm maximizes its profits given its own perceived demand curve, $p_i(Q)$:

$$\frac{d\pi_i}{dq_i} = \frac{dp_i(Q)}{dQ}\frac{dQ}{dq_i} q_i + p_i(Q) - c_i = 0$$

Multiplying and dividing the first quotient by Q/pi,

$$\frac{d\pi}{dq_i} = \frac{1}{\dfrac{\frac{dQ}{Q}}{\frac{dp_i(Q)}{p_i(Q)}}} \frac{p_i(Q)}{Q}\frac{dQ}{dq_i} q_i + p_i(Q) - c_i = 0 \Leftrightarrow$$

and noting that $\dfrac{\frac{dQ}{Q}}{\frac{dp_i(Q)}{p_i(Q)}}$ measures the percentage change in total demand in response to a given percentage change in firm *i*'s price, i.e., firm i's price elasticity of total demand, η_i, the expression can be rewritten as:

$$\frac{1}{\eta_i}\frac{p_i(Q)}{Q}(1+\gamma_i)q_i + p_i(Q) - c_i = 0 \Leftrightarrow$$

where

$$\gamma_i = \frac{dQ_{-i}}{dq_i}$$

is firm *i*'s conjecture about the reaction of the other firms to a change in its own output. The above expression can be rewritten as:

$$\frac{p_i - c_i}{p_i} = \left(-\frac{1}{\eta_i}\right) s_i (1+\gamma_i)$$

where the left hand term is the Lerner index, and one can think of s_i as the (quality unadjusted) market share of firm *i*.

Further, assuming like Bos (2003) that each firms' marginal costs are constant, and multiplying the left hand side term by q_i,

$$\frac{TR_i - VC_i}{TR_i} = \left(-\frac{1}{\eta_i}\right) s_i (1+\gamma_i)$$

where TR_i and VC_i are firm *i*'s total revenue and variable cost, respectively, which is equivalent to

(1a) $$\frac{\pi_i + FC_i}{TR_i} = \left(-\frac{1}{\eta_i}\right) s_i (1+\gamma_i)$$

where π_i and FC_i are firm *i*'s profits and fixed costs, respectively.

Expression (1a) indicates that the price cost margins of the firm can be calculated from observed measures of profits, fixed costs, and total revenues, and that it is explained by the price elasticity of total demand plus a term that reflects the firm's market share and the firm's conjecture on how other firms react to a change in the firm's own output.

Since the conjecture is not observed, Bos (2003) argues that under the presumption of collusive behavior it is likely that higher market shares are associated with a larger incentive for collusive behavior (higher γ_i). However, contrary to Bos, we argue that in the estimation of this equation, it is not possible to identify both the firm's price elasticity of demand and the firm's conjecture. Therefore, rather than assume that the elasticity of demand is constant across countries and time and rather than inferring the conjecture from market share (Bos, 2003), we estimate the joint term $\left(-\frac{1}{\eta_i}\right)(1+\gamma_i)$, controlling for country and time (years and quarters) effects, in essence assuming that the joint term is constant for the firms in a given country in a given period. Thus, the equation becomes:

(1b) $$\frac{\pi_i + FC_i}{TR_i} = f(s_i, c, y, q)$$

where *f* is a linear function of s_i, *c*, *y*, and *q*, where s_i is the firm *i*'s market share, and *c*, *y*, and *q* are indicator-variables for country, year, and quarter effects respectively. This expression allows for the measurement of the impact of the market share on the firm's price cost margins.[6]

5. Empirical Models and Results

Our empirical models consist of two stochastic equations: a price equation and a price-cost margin equation. The estimation methods include both ordinary least squares and standard quantile-regression techniques due to Koenker and Bassett (1978). The main objective of the econometric analysis consists of looking at the impact of different independent variables on both the mean and the shape of the conditional distribution of dependent variables, prices and price-cost margins. Particularly, quantile-regression techniques aim at the identification of factors affecting the within-groups dispersion of prices, margins and revenues, and in contrast with ordinary least squares estimates that measure mean responses of different (market share) groups.

5.1. Price equation

For the price-equation case, we base our estimation strategy on the following empirical model:

(2) $$\ln p_{icyq} = \alpha_0 + \alpha_1 mshare_{icyq-1} + \alpha_2 churn_{icyq-1} + \alpha_3 mpp + \alpha_4 c + \alpha_5 y + \alpha_6 q + \xi_{icyq}$$

where c, q and y are indicator-variables for country, quarter and year effects respectively, while ξ is an unexplained residual.

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[6] While it would be possible to transform (1a) in a linear function by applying logarithms, the transformation would eliminate all observations were the firm profitability is negative. Therefore, we

The dependent variable is the logarithm of the revenue per minute. Since revenue per minute, market share, and churn rates are endogenous variables, we include both *mshare* and *churn* lagged (prior quarter data) to avoid biased estimates due to endogeneity. We estimate two versions of model (2) which mainly differ in the measure of the dependent variable. In the baseline analysis (which we designate *Definition 1* – see Table 3a in Appendix 2), all local currencies are converted to euros at the 2004 annual foreign exchange rate. Definition 1 is calculated using historic nominal prices (revenue per minute) in local currencies as estimated by Merrill Lynch divided by the 2004 nominal average exchange rate of the local currency to the Euro. In the cases where ML reports revenue per minute in US dollars, this amount is converted to the local currency first by using the average US-local currency exchange rate in the relevant quarter. We also run our analysis converting quarterly prices by means of nominal quarterly exchange rates to the euro (*Definition 2* – Table 3b). To verify that our results are not the being driven by exchange rate fluctuations, we also run the analysis only for the Eurozone countries available in the ML sample (i.e., includes all Eurozone countries except Luxembourg) and present the results under Table 3c (*Definition 3*). In none of our specifications do we adjust the revenues per minute for any price deflators such as the GDP deflator, other than the average effect captured in the country specific controls.

Merrill Lynch calculates the firms' market share (*mshare*) as the ratio of the number of subscribers to total subscribers in the country, rather than other alternative measures.[7]

As the ML dataset does not include any cost data we use the churn-rate data (rate of loss of subscribers per month) as a proxy for the firm's marginal costs since the so-called subscriber acquisition and maintenance costs associated with subscriber churn constitutes

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specify (1b) as a linear function of the variables.

[7] There are other forms of calculating market shares (in terms of overall revenues and in terms of minutes of carried traffic) and the number of subscribers may depend on the operators definition of active and inactive subscribers, but this is typically the variable most observed by operators, and one that is likely to have more impact on pricing power, since subscribers have to incur in some transaction costs to change operators.

one of the major cost factors of operators in mature markets. Mobile operators churn rates of between 18% and 36% per year are quite common.[8] Recent US data shows that some of the national operators lose two of their existing customers for every three new customers and a financial analyst has considered churn the largest cost factor of the industry[9], representing 20% of revenues. In fact, firms in this industry often report subscriber acquisition costs as a metric for financial market evaluation. Our argument is that a higher level of churn will lead operators to increase expenditures in order to generate additional minutes of traffic, for example by offering free minutes of calls, which generate additional traffic but also increase the operators' marginal cost[10]. Two opposing hypotheses are consistent with the finding of higher churn rates. On the one hand, higher churn would be associated with higher marginal costs, and thus be expected to result in a higher level of prices. On the other hand, a higher churn rate might signal to the operator that its subscribers are leaving to other operators with lower prices, creating an incentive for the operator to respond by lowering prices.

In MPP (Mobile Party Pays) countries, Merrill Lynch indicates that the number of minutes of calls may be overestimated by around 20%, due to the counting of minutes of incoming calls from own network (on-net), which are free and not billed in most other countries. To control for this we include in the price equation the *mpp* dummy, which is expected to have a negative sign, i.e., revenue per minute is expected to be lower in countries where the traffic measure also includes incoming minutes of calls from own network, since essentially in these countries one is counting these minutes twice *vis a vis*

[8] In some countries, and following the introduction of mobile number portability, churn rates can even be higher. According to the Merrill Lynch Wireless Global Matrix 2Q2004, The average churn rate of Indian mobile operators in the 2Q2004 was 7,5%, which means that per year, not accounting for market growth, 90% of subscribers change mobile operators. According to Mark Rockwell, April 1, 2003, "Overseas LNP: From Benign To Catastrophic", WirelessWeek.com, following the introduction of mobile number portability, monthly churn rates reached 10% in Hong-Kong.

[9] Source: FCC 10th CMRS Report, paragraph 149, p. 56, quoting Timothy Horan et al., Raising Wireless Subscriber; Profitability Outlook Improving, CIBC World Markets.

[10] It has been pointed out that churn could alternatively be considered as a "fixed" cost per subscriber, i.e., a cost of doing business, for example the costs associated with marketing or additional customer service representatives.

non-MPP countries.

Ordinary least squares

Estimation results based on ordinary least squares (OLS) are presented in Table 3a, 3b, and 3c of Appendix 2. The results of the baseline model (2) using the average foreign exchange rate for 2004 (Table 3a - *Definition 1*) suggest that a one percentage point increase in the market share results in 0,23% increase in the price (average revenue per minute). Interestingly, for firms with market shares below the mean of the sample (28,5%), a one percentage point increase in the market share results in a 1,11% increase in the price, whereas for firms with market share above the mean the effect of the market share on price is not statistically significantly different from zero, i.e. the market share seems to have no incremental impact on prices. The results we obtain are robust across the different specifications of how we treat variations in exchange rates (see Table 3b with Definition 2). We obtain similar results for Eurozone countries sub-sample, which suggests our results are not being driven by the effect of exchange rate fluctuations. For Eurozone countries, we find that a one percentage point increase in market share results in 0,46% increase in revenue per minute, but for firms with small market share it results in a 1,84% increase in revenue per minute, whereas for firms with large market share the effect of the market share on price is not statistically significantly different from zero (see Table 3c – Definition 3).

The result shows that firms with lower market shares respond to increases in market share with a significant increase in prices, whereas firms with large market shares will not change their prices in response to marginal changes in their market share. It could be the case that incumbents with large market shares are willing to tolerate a loss in market share without lowering prices, whereas small firms see rising market shares as an opportunity to raise profits by raising prices (thus competing less aggressively). It may also be the case that fringe firms (presumably, new entrants) in this industry are willing to temporarily support a period of low prices in order to compensate their subscribers for a lack of network externalities. Once these firms' market shares rise, creating network effects for their subscribers, they are able to raise prices. Yet another alternative explanation is that the pattern of traffic (i.e. the representative minute) may be substantially and systematically different between small and large firms. If market share is always associated with a specific pattern (or mix) of traffic, then the observed results may simply reflect the difference in the "perceived quality" of the good rather than differences in market power and/or efficiency.

As mentioned in Section 2, the two branches of the literature argue for either a market power hypothesis, where firms use their market power to raise prices, and/or the efficiency hypothesis, where larger firms have lower costs and thus higher price-cost margins. The results suggest that at least for firms with small market share, the increase in the price-cost margins (see also results of margin equation in Section 5.2) is at least to some extent achieved through higher prices.

For all cases, country, year, and quarter effects are jointly significant, which supports our hypothesis that some of the difference in the level of prices is explained by country specific effects such as income or wealth effects.

As expected in countries where on-net incoming call minutes are billed and included the measure of traffic (*mpp=1*), revenue per minute is lower in comparison to most countries worldwide that do not include on-net incoming calls in the measure of traffic, essentially since on-net incoming calls are double counted.

The estimates of the coefficient for the churn rate in the prior quarter, while negative for all specifications are not statistically significant at conventional levels, for both firms with small and large market shares, which seems to suggest that firms do not alter their pricing strategy in response to changes in the churn rate in the previous quarter.

Quantile regression

Model (2) is also estimated using quantile-regression (QR) techniques as described by Koenker and Bassett (1978). A quantile regression provides complementary information to that obtained through ordinary least squares. It permits one to assess the impact of a change in an explanatory variable not only on the mean but also on the shape of the conditional distribution of prices. Putting it differently, QR techniques allow estimating the impact of a specific independent-variable change at several quantiles of the price distribution. Specifically, using model (2), we find that an increase in market share results *ceteris paribus* in a reduction of the within-groups price dispersion as the low-price firms will increase their price much more than high-price firms (Figure 1).

Firms in the lowest decile of the conditional price distribution respond to an increase of one percentage point in the market share with a 0,5% increase in prices, whereas firms in the highest decile respond to the same market-share increase with a 0,13% increase in prices, i.e., low price firms have a four times larger response to gains in market share. Similar results are obtained if one uses quarterly exchange rates and in the sample of Eurozone countries (see Figures 2 and 3), although for Eurozone countries the difference in responses is less pronounced (a two times larger response only).

Our quantile-regression results support and complement the results of the OLS analysis that showed differing behaviour by firms with large and small market shares. The quantile regression indicates, for firms with low prices, an increase in the market share of firms has a more pronounced effect on prices than in markets where prices are already high.

5.2. Price-cost margin equation

Both theory and previous empirical analyses in industrial organization suggest that there is likely to be a positive relationship between a firm's market share and its price-cost margin, both on market power and efficiency grounds. According to the model presented in section 4, an increase (decrease) in the market share is associated with an increase (decrease) in the price mark-up, *ceteris paribus*. This occurs because cost or quality differences affect both market shares and margins in equilibrium.

An issue in the analysis of price-cost margins concerns the definition of the left-hand-side variable in equation (1b). As explained in Appendix 1 we use EBITDA (earnings before interest, taxes, depreciation, and amortization) as our measure of price-cost margins, and our estimation strategy is based on the following model, where we extend the margin equation (1b) derived in Section 4 model by including a control for subscribers' churn costs, in order to make the analysis comparable to the price equation analysis of model (2):

(3) $$ebitda_{icyq} = \alpha_0 + \alpha_1 mshare_{icyq-1} + \alpha_2 churn_{icyq-1} + \alpha_3 c + \alpha_4 y + \alpha_5 q + \xi_{icyq}$$

Ordinary least squares

Our main empirical result for model (3) is that the lagged market share has a positive statistically significant effect on the ebitda margin. In the baseline model (3) using the ML sample, an increase of one percentage point in the market share results in an increase of 0,70 percentage points in the ebitda margin on the overall sample (see Table 4a). Moreover, for firms with market share smaller than the average (28,5%), an increase of one percentage point in the market share results in an increase of 1,87 percentage points in the ebitda margin, whereas for firms with large market share a one percentage point increase in the market share results in an increase of 0,43 percentage points in the ebitda margin, suggesting that the bulk of the increase in profitability is achieved by firms with low market shares. Further, we obtain consistent results if we consider a sub-sample including only Eurozone countries (see Table 4b), if we specify the model following (1b), i.e., without controlling for the churn rate, or if we use a log-linear transformation of equation (1a), rather than equation (1b) expressed in linear form.

Model (3) suggests that firms with large market share have a smaller incentive to increase market share than firms with small market shares, i.e., the increase in profitability with market share is larger for firms with small market share than for firms with large market share, *ceteris paribus*. Further, model (2) indicates that firms with small market shares respond to a drop in market share by lowering prices significantly whereas firms with large market share do not change their prices, suggesting firms with large market share refrain from competing aggressively on price maybe because firms with large market share have less to gain than firms with small market share by doing so. Of course there might be other causes for this result, including biases related to different underlying patterns of traffic for large and small firms (as discussed earlier) or for example a more intensive regulatory supervision of firms with large market share.

Quantile regression

Our main empirical result is that an increase (decrease) in the market share reduces (increases) the dispersion of margins (see Figures 4 and 5). Indeed, we find that the incremental impact of market share on EBITDA margins is decreasing along the margins distribution. This result is, in our view, not surprising as we focus on the market for mobile-phone services, characterized by few operators in each country, each one with a relatively high market share (mean of 28,5%). We deal with an industry whose basic features are very different from those for a competitive industry. In the context of this differentiated oligopoly, which in terms of market structure is closer to the monopoly case than to the perfect competition case, it is reasonable to expect a negative impact of market share on the within-groups dispersion of margins.

As expected, a decrease in the market share reduces the EBITDA margin on average, although the distributional impact is quite heterogeneous. In response to the same change, high-margin firms seem to reduce their price-cost margins much less than low-margin firms.

These results reinforce and complement the prior results obtained with the price equation (2) and with ordinary least squares. In theory, one expects to find firms with low price-cost margins either if prices are low, i.e., competitive markets, or in markets with inefficient firms, i.e., costs are high. The results indicate that for firms with low price-cost margins an increase in the market share results in a higher increase in the price-cost margin than for firms with high price-cost margin, *ceteris paribus*. Both hypotheses, market power increase and efficiency improvements are consistent with this result, but when considered jointly with the price equation (see Tables 3a, 3b, and 3c), the results suggest that at least part of the improvements in our proxy of the price-cost margin are attributable to price increases, and that this rising effect of the margin is highest in the lowest margin quantile. Of course, as specified in our model, differences in price could reflect differences in quality, and hence could be consistent with the efficiency hypothesis.

6. Analysis of the Portuguese market

Table 5 describes the evolution of the Portuguese mobile telecommunications operators' main variables in the period between the first quarter of 1999 and the second quarter of 2004. Table 6 summarizes the evolution of non-weighted revenue per minute (and the respective standard deviation) in a sample of Eurozone countries (i.e., it excludes Luxembourg) from 1999 to the first half of 2004.

The mobile operators in Portugal have had differing experiences with regard to market share and price (average revenue per minute). TMN seems to have maintained and slightly increased its market share, but consistent with the overall sample results, increases in its market share have not resulted in an increase in its price. In fact, throughout the period of the sample TMN has often had average or below average price. Despite its low prices, it has achieved the highest profitability in the industry and has increased its profitability over time. This suggests that TMN is the most cost-efficient operator. Vodafone seems to have been willing to tolerate a loss in market share, whereas interestingly Optimus has in most years had higher prices than average, while at the same time making substantial strides in both the market share and in its price-cost margin (ebitda). On the other hand, research by Gagnepain and Pereira (2005) suggests that the entry of Optimus in 1998 contributed to raising overall industry efficiency.

As seen in Table 5, the concentration of the industry (Herfindahl-Hirschman Index or HHI) has varied less than 200 points between 1999 and 2004, but it hovers 300 points above the theoretical minimum with three firms, i.e., using the HHI measure the industry seems slightly more concentrated than the theoretical best with three firms (each with a market share of 33%).

6.1. Analysis of the Portuguese mobile voice prices evolution

Non-weighted revenue per minute averaged 0,21€ at market prices in this period, 14,2% higher than the mean revenue per minute in the ML sample of 47 countries using the

2004 Euro exchange rates, but just 1,4% higher than the average if using quarterly exchange rates to compare prices. However, revenue per minute went from 74,2% to 128,3% of the ML sample average in this period, again at 2004 exchange rates. Although some of this evolution is due to exchange rate fluctuations, a comparison with the evolution of prices in the Eurozone countries of the sample also shows that revenue per minute has fallen in Portugal by less than in other Eurozone countries. The non-weighted mean revenue per minute (in nominal terms) went from 72,8% of the Eurozone average (or 0,239€) in the first half of 1999 to 94% of the Eurozone average (or 0,197€) in the first half of 2004, and there is some evidence that Eurozone prices did not fall by nearly as much as World average prices. As seen in Table 6 from 1999 to the first half of 2004, the non-weighted average revenue per minute in Portugal changed from the second lowest to the fourth lowest of the Eurozone countries in the ML sample.

Since 2000 there has been a growing regulatory intervention of ICP-ANACOM and other European telecom regulators, perhaps as a result of the lack of satisfactory evolution of prices (see Section 2.1 of ICP-ANACOM, 2005b). In particular, ICP-ANACOM imposed or negotiated reductions in the maximum wholesale rates of mobile-to-mobile and mobile-to-fixed termination calls (off-net incoming). These reductions in price were substantial and, according to ICP-ANACOM, in this period the operators set their termination rates at the maximum allowed levels. For example, the maximum fixed-to-mobile and mobile-to-mobile per-minute termination rates for a 100 second call fell from 0.274€ in 1999 to 0.185€ in March 2005[11]. The reductions imposed by ICP-ANACOM from 1999 to 2004 are equivalent to an average 6.3% annual decrease of wholesale termination rates. In that same period average revenue per minute in Portugal (including wholesale termination and retail traffic) decreased by the equivalent of 3.8% annually, so retail prices (which are not regulated in the same manner) declined by much less than wholesale prices. Interestingly, most of the

[11] Optimus could set a higher fixed-to-mobile termination rate, which was 0.277€ in March 2005, 50% higher than the other two operators.

reduction in the average revenue per minute occurs in just two years (2000 and 2002), with average revenue per minute remaining stable or increasing slightly in the remaining period of the sample. Thus, the data raises the interesting question of whether the observed industry performance in these years is consistent to what Harrington (2005) calls structural break in firm behavior, for example due to price wars among companies.

Wholesale termination rates for off-net incoming traffic have historically been higher than on-net rates. They represent a significant part of the operators' revenues and traffic, and are used to calculate average revenue per minute (see also Appendix 1). For example, in 2004 TMN derived 6.1€ (or 25%) of its subscriber ARPU from interconnection revenues, down from 8.1€ (or 30% of subscriber ARPU) in 2002. Thus, as acknowledged by the operators in their financial reports (Portugal Telecom - TMN, 2000-2004; Optimus, 2003-2004; Vodafone, 2003-2005), the reduction in interconnection rates imposed by ICP-ANACOM had a significant impact on the observed reduction in the average revenue per minute in this period. Indeed, in some years of this period the operators increased their retail rates for outgoing calls while being mandated by ICP-ANACOM to reduce their wholesale rates. In summary, the anecdotal evidence available suggests that a substantial part of the observed reduction in the average revenue per minute is the result of regulatory intervention rather than competitive dynamics. Similarly, part of the price reduction in Eurozone countries has resulted from the intervention of national telecom regulatory agencies. Further research is thus necessary to assess the competitive dynamics of the retail market, i.e., excluding the apparently important impact of regulatory intervention in wholesale market prices (and on average revenue per minute).

6.2. Minimal differences in pricing between national operators

The price behavior of the three Portuguese operators is also of interest. In fact, the differences in revenue per minute of the Portuguese operators have tended to be minimal, with deviations from the non-weighted average national revenue per minute under 5 percent between 1999 and 2003. The maximum price difference between lowest and highest price operators was 10% in this period, and in most years less than that. There is a wider difference in the level of prices in the first half of 2004, but this may be due to having only two quarterly observations. This result is surprising, since the measure we are using is the average revenue per minute and it would be reasonable to expect some variation due for example to differences in the perceived quality of the service offered, or to differences in the call mix of operators (see discussion further below). Still, the fact that average revenue per minute deviates little between operators suggests that the operators are keenly aware of their competitors' prices.

One possible explanation for the relatively small differences is price is that firms' have weak pricing power, i.e., competitive forces lead to (near) zero-profit equilibria in which prices do not deviate greatly from marginal costs. A somewhat different explanation is that operators did not engage in aggressive pricing for fear of what Porter (2005) calls dynamic retaliatory behavior, i.e., if an operator lowers its price significantly to increase its market share and profits (under a price competition model) the remaining operators might quickly retaliate by lowering their prices, leading to overall lower prices and lower industry profitability, without changing the initial relative equilibrium. In these conditions an accommodative strategy might be the optimal strategy. In this scenario, fear of a price war can sustain higher prices (Harrington, 2005; Porter, 2005).

The number of observations available does not permit us to elaborate further on these hypotheses. Further research is also required to investigate the extent to which this effect is found in the other countries of the sample.

6.3. Explaining price differences

Optimus, the firm with the smallest market share, has high average revenue per minute even as it increases its market share. This suggests that the consumer choice of the operator is not exclusively based on the price as measured by the average revenue per minute, but is instead also based on some other unobserved characteristics (i.e., perceived quality attributes). It may also be the result of the lack of price transparency given the large number of alternative pricing plans, which may make the relatively small difference in the average revenue per minute imperceptible to the end-user.

Yet other possible explanation to the finding that Optimus has high average revenue per minute is that the call mix (particularly, on-net, off-net, and incoming off-net types of call) of Optimus subscribers is substantially different from that of the two other operators. ICP Anacom (2005a) as well as the European Regulators (ERG, 2004), acknowledge the potential for large firms (incumbents) to use price discrimination to foreclose markets. Particularly, large firms could set their wholesale interconnection prices (incoming off-net) high while implicitly charging internally low interconnection rates (low on-net call prices). Such tariffs would force small firms like Optimus to have high off-net prices and therefore higher average revenue per minute, and basically increase the network externalities associated with belonging to large firms, an effect called "tariff-mediated network externalities" (Laffont and Tirole, 2000). As a result of such tariff structures the call mix might have a significant effect on average revenue per minute.

Some data on the call mix of each operator is available from ICP-ANACOM (2005b). In the first half of 2004 84% of TMN's the mobile-to-mobile outgoing calls were on-net, compared to 64% for Optimus and 73% for Vodafone. Furthermore, in 2003, the termination traffic in each network was approximately 1750 Million minutes and 800 Million minutes for TMN and Optimus, respectively (ICP-ANACOM, 2005a), or 2.2 times larger, whereas TMN's number of subscribers at year end was 2.1 times larger that of Optimus. TMN's interconnection costs were 29% and 28% of operating costs in 2003 and 2004, whereas Optimus' were 27% and 28%, and Vodafone's were 26% and 24% for FY 2004 and FY 2005, suggesting that at the least on the cost side, the impact of interconnections on total operating costs was relatively similar[12]. However, as mentioned above, fixed-to-mobile termination rates favored Optimus from 2002 onwards[13]. Therefore, the limited data available for 2003 and 2004, suggests that the main (call-mix) differences between Optimus and the other operators in Portugal were the percentage of on-net traffic and the termination rates for fixed-to-mobile calls, which have historically been higher than on-net rates (ICP-ANACOM, 2005b).

These two types of calls have differing effects on average revenue per minute. It seems likely that the former effect dominates, i.e., as firms gain market share, a larger proportion of calls are of the cheaper on-net variety (and a smaller proportion of the off-net outgoing variety), driving average revenue per minute down. However, this is not what we find in the econometric analysis nor through the observation of Optimus' prices in this period. Our econometric analysis shows there is a statistically significant positive effect of market share on average revenue per minute. Moreover, the effect is large and significant for firms like Optimus, with market share below the mean of the sample (below 28,5%), but it is not significant for firms with market share above the mean of the sample (Vodafone and TMN in the Portuguese case). Increases in the market share of small firms results in increases in average revenue per minute, whereas the above mentioned effect would be expected to result in decreases in average revenue per minute.

In summary, it seems unlikely that differences in the average revenue per minute between Optimus and the other operators are solely attributable to differences in the call mix. Instead, the results and data available suggest that there is some other alternative cause for the observed price dynamics.

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[12] Note that the interconnection costs include the amount the operators pay for off-net segments of calls, roaming, and circuit leasing costs.

[13] At an European level, in August 2003, the fixed-mobile termination rates for non-SMP operators were 17% higher than those of SMP operators (European Commission, 2004).

6.4. Do our empirical results fit the Portuguese case?

The answer is mixed. Table 7 and 8 report market shares, revenues per minute of call and price-cost margins for the three existing mobile-phone operators in Portugal: TMN, Telecel and Optimus. Particularly, we present means and mean-variations, both related to the sample period of 1999-2004, and based on our quarterly data. Note that the means statistics only capture a small part of the information available in the data, and therefore should be regarded with some caution.

On the one hand, our result of a positive causal relationship going from the market share to the profit-margin and price seems consistent with the observed sample statistics. The higher the market share, the higher the price-cost margin (Table 7) and firms that experience a growth in market share see also growth in price-cost margins (Table 8). On the other hand, however, our result of a positive causal impact of the market share on the price level does not find corresponding evidence in the sample statistics. Indeed, a higher market share, rather than being associated with a higher price level, as we would expect, seems instead associated with a lower revenue per minute of call. There may be some other explanations for this effect (see discussion above).

Regarding Table 8, sample statistics suggest that all three operators lowered their prices during the sample period, despite the fact that two of them, TMN and Optimus, increased their market shares, which at first look seems inconsistent with our econometric results but may be the result of a dominating effect of the time trend towards lower prices. The time trend is captured in our time control dummies in the econometric analysis, but is not reflected in the summary table. In addition, the average increase in the profit margin per unit of average increase in the market share is higher for TMN than for Optimus, which again contradicts our empirical evidence in the sample of 45 countries.

The main explanation of why our results do not generally fit the Portuguese case is obvious. Sample statistics do not capture causal and *ceteris-paribus* relationships as econometric regressions do, for example, the use of means reduces the information available in the data. Nevertheless, we find of interest to point out the existence of some discrepancies.

7. Conclusion and policy implications

Despite difficulties inherent with available data, our paper suggests some interesting results. We find, as expected according to theory, a positive and significant effect between market share and prices and margins, after controlling for country, and time effects. However, for firms with large market shares (above the mean of the sample) there is no statistically significant effect of market shares on prices and the effect of market shares on margins is less pronounced than for firms with market shares below the mean of the sample. On the other hand, for fringe firms, there is a statistically significant positive effect of market shares on prices and margins. Firms with large market shares do not change their behavior (i.e., price) in response to changes in market share whereas fringe firms do, apparently because their incentive to do so is relatively smaller than that of firms with small market shares, i.e., the results suggest firms with large market shares gain proportionally less (i.e., lower increase in price-cost margins) by competing aggressively (e.g., on price) to gain market share.

In addition, the observed behavior of firms with respect to prices and price-cost margins produces some surprising results. The most significant change in performance (in terms of changes in prices and changes in price-cost margins) occurs in markets that were conventionally thought to have a better performance, i.e., firms and/or markets with low prices and low price-cost margins. For example, firms with prices (price-cost margins) in the lowest decile respond to an increase in market share with an approximately 4 (2) times larger increase in prices (price-cost margins) than firms in the highest decile of prices (price cost margins), i.e., low-price (low price-cost margins) firms will increase their price (price-cost margin) much more than high-price (high price-cost margin) firms, in response to an increase in market share. If the lowest prices and lowest price-cost margins are found in the relatively more competitive markets, the results suggest that it is in these markets that prices and margins rise most in response to an increase in market share of the firms.

As for policy implications the paper suggests that, for this particular industry, the Herfindahl-Hirschman Index seems an inadequate instrument on which to base horizontal merger policy analysis. According to our results, some increases in the HHI (those related to gains in market share by firms with large market shares) would have minimal impacts on prices and margins, while smaller increases in the HHI (caused by market share gains by smaller firms) would have more important impacts on prices and margins. Furthermore, firms with large market share of several EU countries have been found to have Significant Market Power (SMP) by the National Regulatory Authorities, and as such have been submitted to a more stringent regulatory regime than firms with small market share (e.g., in terms of price setting behavior). However, our results suggest that it is the firms with small market share, i.e., those now granted non-SMP status, which alter their behavior the most in response to changes in the market share.

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Appendix 1: Revenues, output, price, and profit characterization

In this analysis, we aim at analyzing the operators pricing behavior regarding usage of voice telephone services, i.e. to explain the difference in the level of the operators' average revenue (price) per minute, rather than focus on the consumers' choice of one operator pricing plan over the same or other operators' pricing plan. Our argument is that average revenue per minute together with the number of minutes of traffic are the main determinants of mobile operators' revenues and profits, i.e., they are akin to the operator price and output variables, and in this hypothesis we are partly supported by the Merrill Lynch Global analysts, which consider average revenue per minute a good proxy for price, and by the Federal Communications Commission (2004), which also uses average revenue per minute as one of its proxy for prices. On the other hand, other research (Teligen, 2003; Parker and Röller, 1997; Grzybowski, 2005) has emphasized the usage of prices based on hypothetical baskets of mobile telecommunications consumption, since it is argued that the unit of output (minute) will differ across firms (see discussion further below), but we believe a measure of price based on a basket of mobile telecommunications consumption introduces biases of its own.

Measure of Revenues: Operating revenues net of data and handset revenues

On the revenue side, we focus exclusively on the firm's reported mobile operating revenues, i.e., we discard non-recurring revenues. Currently, in most countries, mobile operators derive most of their operating revenues from voice traffic, which in our context includes retail billed outgoing calls (including roaming) but also wholesale interconnection revenues for incoming calls from other networks, i.e., charges other telecom operators pay to the firm for the terminating leg of the call to a given subscriber plus roaming revenues, where applicable. The only other relevant sources of operating revenues are mobile handset sales and data traffic revenues. ML subtracts handset sales from the measure of revenue, resulting in what is known in the industry as the service revenues. In the calculation of average revenue per minutes, ML further subtracts data traffic revenues from service revenues figures. For the operators in the sample, data revenues represent typically between 5% and 15% of the firms' service revenues. Thus, ML's measure of average revenue per minute includes only voice traffic (outgoing and incoming).

Measure of Output: outgoing plus off-net incoming minutes of voice calls

We consider that the relevant measure of output is the total minutes of voice calls, defined, partially based in the ML methodology, as total duration minutes of billed outgoing calls and incoming calls from other networks rather than other alternative variables.[14] Total minutes of billed traffic (outgoing and incoming from other networks) captures both the change in the traffic usage of existing subscribers and the addition of new subscribers to the network, and it is an often used industry metric that is widely reported. For countries (e.g., Australia, Finland, New Zealand) that only report outgoing traffic, Merrill Lynch adjusts traffic data by assuming that incoming traffic is one third of total traffic, consistent with traffic patterns in these countries and elsewhere. Merrill Lynch does not adjust traffic data in countries where on-net incoming calls (terminating calls from the same network) are also billed (so-called Mobile Party Pays or MPP countries), but estimates that in these countries (US, Canada, China, India, Singapore, Hong Kong) the number of minutes may be overestimated by up to 20%. To account for this effect we include a control dummy for this group of countries.

The use of voice call minutes as a measure of output and demand for services is nonetheless not a perfect measure. A given subscriber's pattern of outgoing and (other network or off-net) incoming minutes of voice traffic is likely to vary widely (e.g., business calls, international calls, peak hour calls, roaming calls, local calls, etc). Furthermore, different subscribers are likely to have different distributions of the different types of calls,

[14] Other alternative measures of demand and output were available. For example, number of subscribers (i.e., subscription of a mobile voice service) is not a satisfactory metric for the firm output or user demand since it is too coarse a measure of usage, traffic per subscriber tends to increase over time and could not be captured in this measure, and any firm strategy directed at changing the traffic patterns of existing subscribers (that for example contributed to an increase in marginal costs) would not be captured if number of subscribers was used as the metric. Number of calls per subscriber could alternatively be used as measure of output, but it is still not as precise as the number of call minutes.

different operators are likely to have a different distribution of subscriber types, and different countries are also likely to have different distributions of operators and subscribers, leading to what in essence are different “typical” voice minutes among subscribers, operators, and countries.

Therefore, in this analysis we are interested in expected values or a representative minute of voice calls, i.e., the measured unit of output is the same (minute of voice call), but the perceived quality of the unit of output and respective price may differ across operators, i.e., there is a differentiated oligopoly. Differences in our measure of output (representative minute of outgoing voice and off-net incoming voice calls) between countries are controlled for by using a country dummy in our model. Thus, our analysis, is simplified since we assume that the relevant output can be “standardized” into a unit of account that is a representative minute of outgoing and off-net incoming voice calls. We accept that while we standardize the unit of output to the “representative” minute, we are unable to compare its “perceived quality” across firms, i.e., differing levels of prices may result from different levels of perceived quality, for example because of systematically different proportions of outgoing and incoming calls or different proportions of on-net and off-net outgoing and incoming calls.

Measure of Price: average revenue per minute

The relevant measure of price is average revenue per minute, which ML defines as the voice-only average revenue per user (ARPU) divided by the number of minutes per user. Merrill Lynch adjusts revenue per minute by subtracting data and handset revenues from ARPU, so as to include in the calculation of the revenue per minute only voice traffic revenue (including interconnection revenues from incoming calls billed to third parties and roaming revenues). Note that it is likely that the operators can only imperfectly fine-tune the average revenue per minute (e.g., through definition of different price plans or base minute prices), although it is a measure that the operators often monitor and report, and is followed by industry analysts. Indeed in some mature markets operators have managed to maintain or even increase average revenue per minute, suggesting operators are keenly aware of the impact of average revenue per minute on revenues and profitability. Finally, it should be noted that there is some double counting of revenues in the measure of average revenue per minute, in the sense that for most operators some of the incoming traffic generates interconnection revenues for the mobile operators that are paid by other mobile operators out of outgoing call revenues. ML indicates that in countries where the calling party pays interconnection revenues amount to about 20% of revenues. Thus, if two firms were to merge, *ceteris paribus*, the combined firm revenues might decline since each firm would lose the interconnection revenues. While we would wish to correct for this effect, the necessary data is not available in the ML sample.

<u>Measure of economic profits: EBITDA</u>

There is a large literature on the problems of using accounting data and accounting measures of profitability to estimate economic profits and price-cost margins (Schmalensee, 1989). From an accounting perspective, there is a difference in profitability if the investment is financed with own capital or external capital (debt). Thus, we prefer a measure of profitability that does not include interest paid, which means that our measure of profitability does not vary depending on the firm capital structure, excludes non-recurrent revenues and costs, i.e. operating profits, and for that matter a measure that also excludes taxes, which differ across countries, i.e., our preferred measure of economic profitability is the accounting operating EBIT (operating earnings before interest and taxes).

An additional issue in the identification of the left-hand-side variable in equation (1b) is what, if any, accounting data may be used as an estimate of the economic fixed costs. While subject to differing definitions and treatments, the depreciation costs (plus the leased infrastructure costs) represent an accountants' estimate of the yearly impairment of the capital equipment, and are thus a proxy for the yearly installment of the long-run fixed costs, although one that is highly criticized in the academic literature (Schmalensee, 1989), namely given the distortions introduced by tax policy.[15]

Thus, our measure for the economic price-cost margins, which we showed was $\frac{\pi_i + FC_i}{TR_i}$ in expression (1b) is measured by accounting profits (EBIT) plus the accountants estimate of the long term fixed costs (depreciation and amortization) over total revenue, which corresponds to the ratio between ebitda (earnings before interest taxes depreciation and amortization) and operating revenues, the so-called *ebitda* margin. Thus, the ebitda margin (hereinafter sometimes referred simply as ebitda) is our proxy for the firm's price-cost margins.

[15] There is a difference in the way accounting profits and costs are measured depending on whether the operator decides to own or to lease part of the infrastructure equipment, which ideally we would wish to correct for, but which is not possible with the dataset available. If part of the infrastructure is leased then the firm reports higher operating costs and lower profits (EBIT) than in the case where the firm entirely owns the infrastructure. Again, using an economic profit definition, the leasing costs should be a part of the long term fixed costs of the operator, i.e., operators that own (rather than lease) a similar infrastructure see these costs reflected in their capital depreciation costs.

Appendix 2: Tables

Table 1 Summary Statistics: ML data-set

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda	2482	.2698711	.3758306	-9.17	.77
mshare	3390	.2849646	.1762797	.01	.95
mpp	3760	-	-	0	1
churn	2074	.0222358	.0173909	.001	.4
rpm_eur~2004	2107	.1845952	.0938925	.0262	1.065
rpm_forex_q	2107	.2079603	.1000279	.027	1.14

Table 2 Summary Statistics: ML Eurozone data-set

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda	692	.1933671	.614389	-9.17	.57
mshare	813	.2971095	.1741952	.01	.69
churn	508	.0173386	.0058068	.006	.042
rpm_eur~2004	538	.2476766	.0716342	.12	.63

Table 3a Price equation (ML data-set)

Dependent variable: logarithm of revenue per minute calculated using 2004 nominal exchange rates - definition 1

	(1)	(2)	(3)
	full sample	mshare below mean	mshare above mean
lgmshare	0.229 (0.000)	1.107 (0.000)	0.032 (0.716)
lgchurn	-1.133 (0.203)	-2.426 (0.149)	-1.195 (0.216)
mpp	-0.527 (0.000)	-2.244 (0.000)	0.440 (0.000)
Observations	1658	718	940
R-squared	0.874	0.862	0.920

Robust p values in parentheses. Regression controls include country, year and quarter effects; all are jointly significant at the 1% level.

Table 3b Price equation (ML data-set)

Dependent variable: logarithm of revenue per minute calculated using quarterly nominal exchange rates - definition 2

	(1)	(2)	(3)
	full sample	mshare below mean	mshare above mean
lgmshare	0.211 (0.000)	1.155 (0.000)	0.006 (0.948)
lgchurn	-1.268 (0.163)	-2.302 (0.170)	-1.671 (0.117)
mpp	-0.592 (0.000)	-1.961 (0.000)	0.245 (0.000)
Observations	1658	718	940
R-squared	0.831	0.838	0.877

Robust p values in parentheses. Regression controls include country, year and quarter effects; all are jointly significant at the 1% level.

Table 3c Price equation (ML Eurozone data-set)

Dependent variable: logarithm of revenue per minute calculated using nominal Eurozone exchange rates - definition 1

	(1)	(2)	(3)
	full sample	mshare below mean	mshare above mean
lgmshare	0.459 (0.000)	1.841 (0.000)	0.119 (0.142)
lgchurn	0.603 (0.602)	-2.046 (0.213)	2.352 (0.161)
Observations	457	119	338
R-squared	0.827	0.882	0.842

Robust p values in parentheses. Regression controls include country, year and quarter effects; country and year effects are jointly significant at the 1% level; quarter effects are not jointly significant at 5% level.

Table 4a Price-cost margin equation (ML data-set)

Dependent variable: ebitda margin

	(1)	(2)	(3)
	full sample	mshare below mean	mshare above mean
lgmshare	0.696 (0.000)	1.869 (0.000)	0.432 (0.000)
lgchurn	-0.131 (0.535)	0.654 (0.024)	-0.696 (0.002)
Observations	1846	784	1062
R-squared	0.560	0.576	0.663

Robust p values in parentheses. Regression controls include country, year and quarter effects; country and year effects are jointly significant at the 1% level; quarter effects are not jointly significant at 5% level

Table 4b Price-cost margin equation (ML Eurozone data-set)

Dependent variable: ebitda margin

	(1)	(2)	(3)
	full sample	mshare below mean	mshare above mean
lgmshare	1.080 (0.000)	3.760 (0.000)	0.535 (0.000)
lgchurn	0.430 (0.800)	-2.918 (0.373)	0.087 (0.928)
Observations	468	137	331
R-squared	0.667	0.784	0.679

Robust p values in parentheses. Regression controls include country, year and quarter effects; country and year effects are jointly significant at the 1% level; quarter effects are not jointly significant at 5% level

Table 5 Portuguese mobile operators – descriptive statistics (ML data-set)

Portuguese Mobile Operators variables

Firm	Year	Market share	Ebitda Margin	Rpm (€)	avg_rpm ortugal	% of average	HHI	Arpu (€)	Avg. No. Customers	Churn rate	Min. of Use
Telecel	1999	39,5%	36,5%	0,240	0,239	100,35	3861	33,75	1569	2,5%	141,5
Telecel	2000	35,5%	34,8%	0,208	0,217	95,77	3654	33,25	1997	2,1%	153,3
Telecel	2001	33,5%	29,0%	0,210	0,218	96,18	3577	30,00	2625	2,0%	136,8
Telecel	2002	32,0%	29,5%	0,190	0,193	98,70	3556	27,25	2935	2,1%	136,3
Telecel	2003	32,0%	27,5%	0,198	0,194	101,72	3624	26,75	3197	2,1%	125,0
Telecel	2004	32,0%	30,5%	0,215	0,197	109,32	3680	28,50	3284	2,1%	121,5
TMN	1999	45,5%	35,5%	0,238	0,239	99,30	3861	30,25	1817	2,1%	126,8
TMN	2000	44,8%	37,0%	0,215	0,217	99,23	3654	30,75	2522	1,9%	137,8
TMN	2001	44,5%	38,5%	0,220	0,218	100,76	3577	30,00	3505	1,4%	127,0
TMN	2002	45,3%	42,3%	0,193	0,193	100,00	3556	27,00	4170	1,6%	130,5
TMN	2003	46,0%	45,3%	0,188	0,194	96,57	3624	25,25	4639	2,0%	123,3
TMN	2004	47,5%	47,5%	0,180	0,197	91,53	3680	24,00	4898	2,0%	119,0
Optimus	1999	14,8%	13,5%	0,240	0,239	100,35	3861	31,00	609		128,3
Optimus	2000	19,8%	11,0%	0,228	0,217	105,00	3654	32,25	1120		135,0
Optimus	2001	21,8%	12,8%	0,225	0,218	103,05	3577	28,25	1717		118,3
Optimus	2002	22,0%	17,8%	0,195	0,193	101,30	3556	24,25	2038		112,3
Optimus	2003	22,0%	23,0%	0,198	0,194	101,72	3624	22,50	2226		104,3
Optimus	2004	20,0%	29,0%	0,195	0,197	99,15	3680	24,00	2091		109,5

ML sample(annual averages of quarterly values)

Table 6 Eurozone countries - average revenue per minute and standard deviation statistics (ML data-set)

Country	Year 1999	2000	2001	2002	2003	2004
Austria	0,365	0,289	0,251	0,238	0,238	0,233
	0,043	0,030	0,042	0,035	0,033	0,043
Belgium		0,220	0,235	0,235	0,223	0,200
		0,000	0,006	0,013	0,017	0,014
Finland	0,189	0,180	0,175	0,165	0,154	0,143
	0,018	0,013	0,017	0,014	0,011	0,005
France	0,278	0,228	0,170	0,158	0,154	0,143
	0,074	0,044	0,041	0,032	0,021	0,016
Germany	0,404	0,322	0,292	0,279	0,273	0,260
	0,045	0,046	0,026	0,037	0,044	0,042
Greece	0,489	0,397	0,312	0,268	0,251	0,231
	0,073	0,031	0,031	0,013	0,024	0,031
Ireland			0,210	0,208	0,195	0,185
			0,017	0,005	0,006	0,007
Italy	0,280	0,248	0,218	0,213	0,215	0,208
	0,008	0,019	0,013	0,012	0,009	0,008
Netherlands	0,331	0,279	0,250	0,238	0,243	0,227
	0,022	0,018	0,022	0,040	0,044	0,042
Portugal	0,239	0,217	0,218	0,193	0,194	0,197
	0,016	0,010	0,010	0,009	0,008	0,019
Spain	0,310	0,290	0,260	0,243	0,225	0,220
	0,026	0,016	0,008	0,010	0,006	0,000
Average	0,325	0,271	0,240	0,224	0,220	0,209
	0,095	0,067	0,052	0,048	0,048	0,046

Table 7. Sample averages for Portuguese operators

-> firm = Optimus

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda	22	.1681818	.0623841	.04	.32
mshare	22	.2004545	.0291919	.11	.22
rpm_eur~2004	22	.215	.0208738	.18	.26

-> firm = TMN

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda	22	.4040909	.0461529	.32	.48
mshare	22	.4540909	.0095912	.44	.48
rpm_eur~2004	22	.2077273	.0215874	.18	.26

-> firm = Telecel

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda	22	.3136364	.0504782	.22	.41
mshare	22	.3427273	.0311955	.32	.44
rpm_eur~2004	22	.2095455	.01939	.18	.26

Table 8. Sample mean-variations for Portuguese operators

-> firm = Optimus

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda_cha~e	21	.0090476	.0384584	-.08	.08
mshare_cha~e	21	.0042857	.0112122	-.02	.04
rpm_eur_fo~e	21	-.0028571	.0123056	-.03	.01

-> firm = TMN

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda_cha~e	21	.007619	.0304803	-.05	.08
mshare_cha~e	21	.0009524	.0070034	-.01	.02
rpm_eur_fo~e	21	-.0038095	.0124403	-.04	.02

-> firm = Telecel

Variable	Obs	Mean	Std. Dev.	Min	Max
ebitda_cha~e	21	-.0038095	.0486288	-.16	.08
mshare_cha~e	21	-.0057143	.0112122	-.05	0
rpm_eur_fo~e	21	-.0014286	.0127615	-.02	.03

Table 9 ML Sample description

Country	Freq.	Percent	Cum.
Alemanha	88	2.34	2.34
Argentina	88	2.34	4.68
Australia	81	2.15	6.84
Austria	108	2.87	9.71
Brasil	108	2.87	12.58
Bélgica	66	1.76	14.34
Canadá	88	2.34	16.68
Chile	88	2.34	19.02
China	66	1.76	20.77
Colombia	66	1.76	22.53
Coreia	66	1.76	24.28
Dinamarca	108	2.87	27.15
Egipto	44	1.17	28.32
Finlândia	87	2.31	30.64
France	66	1.76	32.39
Grécia	87	2.31	34.71
Hong Kong	132	3.51	38.22
Hungria	66	1.76	39.97
Indonésia	66	1.76	41.73
Irlanda	63	1.68	43.40
Israel	88	2.34	45.74
Itália	87	2.31	48.06
Japão	154	4.10	52.15
Malásia	66	1.76	53.91
México	109	2.90	56.81
Netherlands	110	2.93	59.73
New Zealand	44	1.17	60.90
Norway	44	1.17	62.07
Philippines	66	1.76	63.83
Poland	66	1.76	65.59
Portugal	66	1.76	67.34
República Checa	66	1.76	69.10
Russia	66	1.76	70.85
Singapore	66	1.76	72.61
South Africa	54	1.44	74.04
Spain	66	1.76	75.80
Sweden	66	1.76	77.55
Switzerland	66	1.76	79.31
Taiwan	132	3.51	82.82
Thailand	125	3.32	86.14
Turkey	66	1.76	87.90
UK	106	2.82	90.72
USA	154	4.10	94.81
Venezuela	88	2.34	97.15
Índia	107	2.85	100.00
Total	3,760	100.00	

year	Freq.	Percent	Cum.
1999	683	18.16	18.16
2000	685	18.22	36.38
2001	683	18.16	54.55
2002	686	18.24	72.79
2003	681	18.11	90.90
2004	342	9.10	100.00
Total	3,760	100.00	

Quarter	Freq.	Percent	Cum.
1	1,025	27.26	27.26
2	1,027	27.31	54.57
3	854	22.71	77.29
4	854	22.71	100.00
Total	3,760	100.00	

Appendix 3: Figures

Figure 1 : Quantile Regression

Dependent variable: lnrpm_eur_forex2004

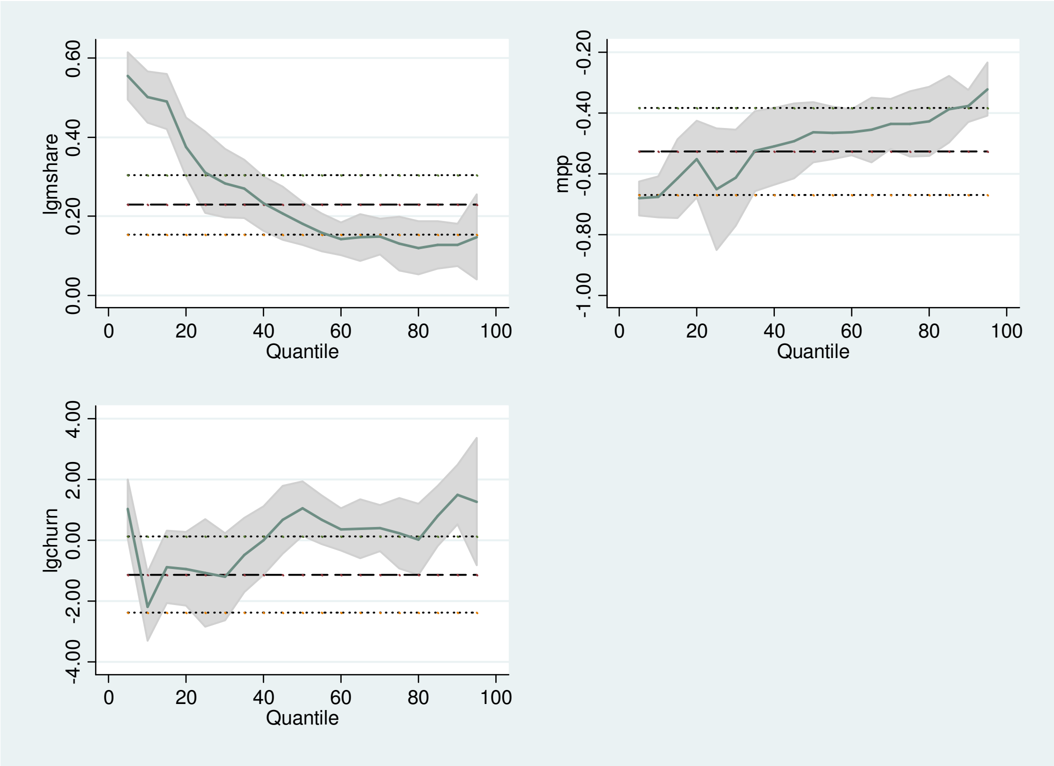


Figure 2: Quantile Regression

Dependent variable: lnrpm_forex_q

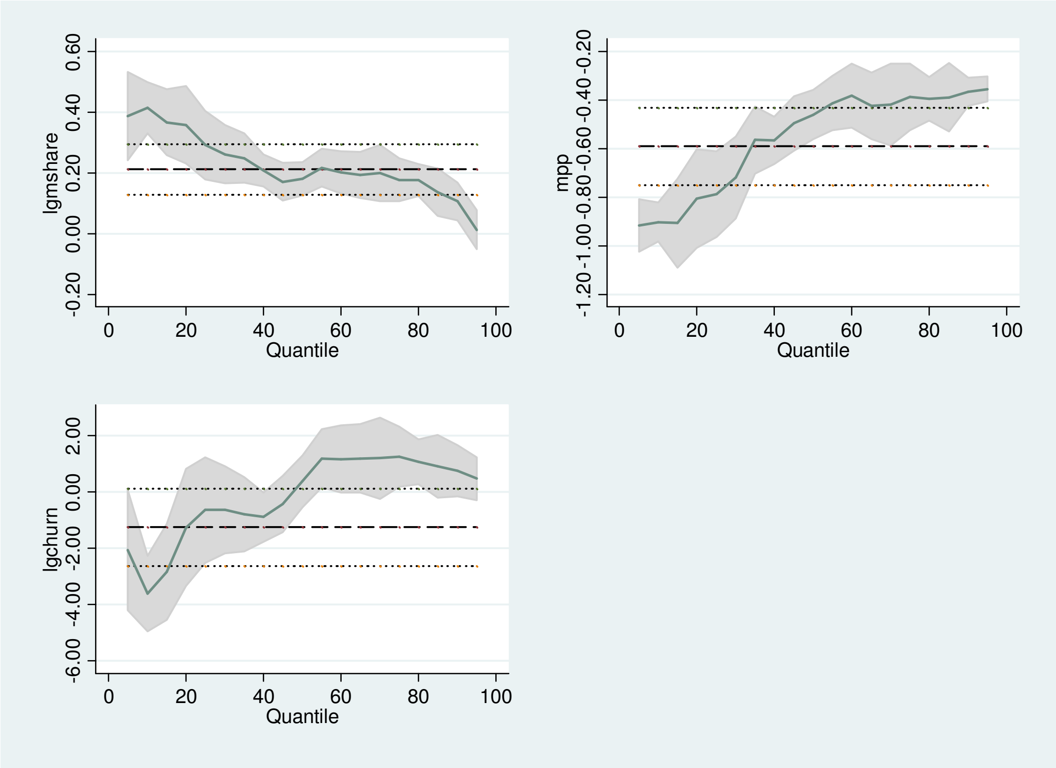


Figure 3: Quantile Regression

Eurozone sub-sample: Dependent variable: lnrpm_eur_forex2004

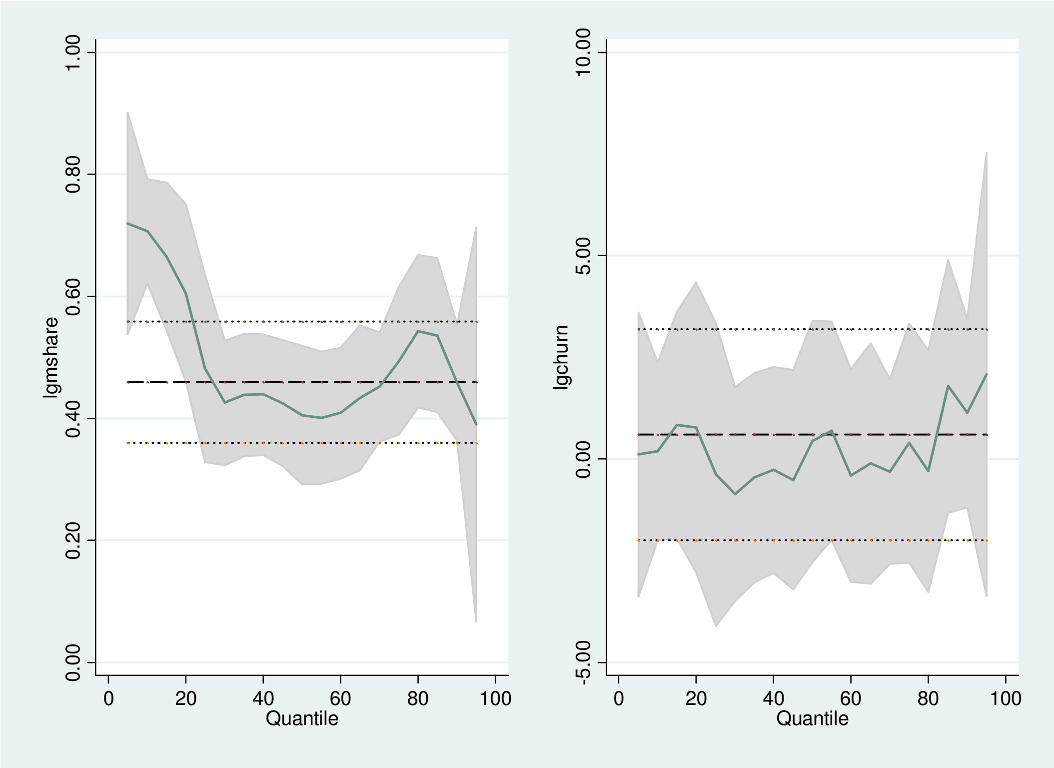


Figure 4: Quantile Regression

Dependent variable: ebitda margin (ML dataset)

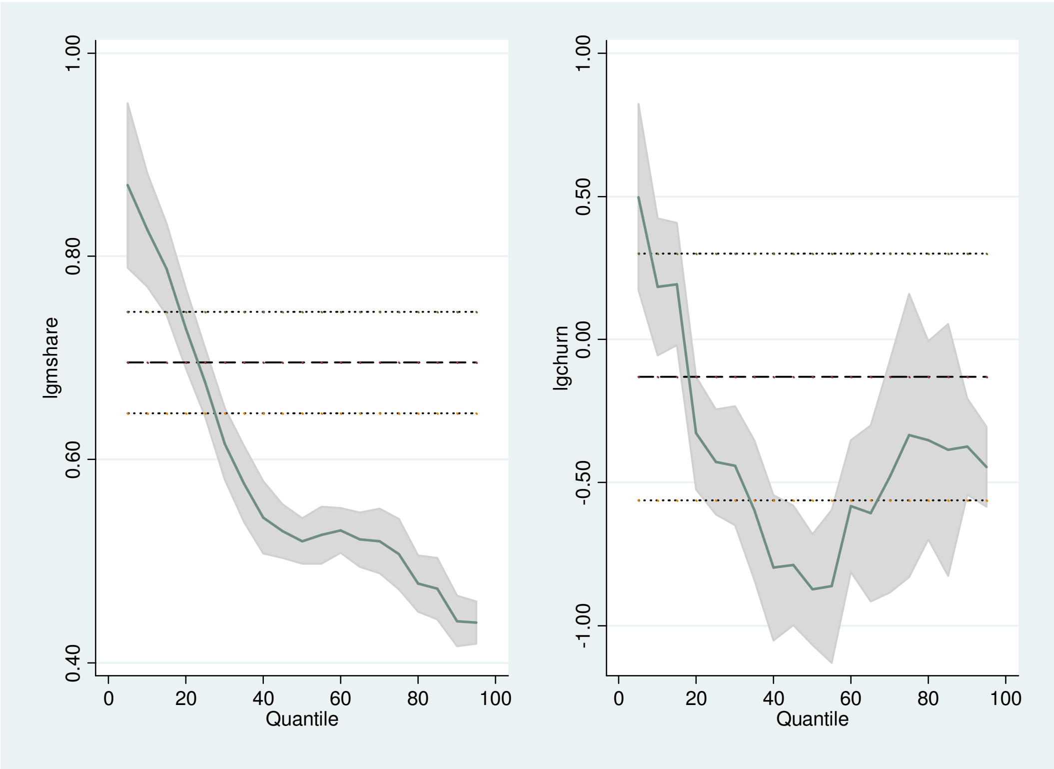
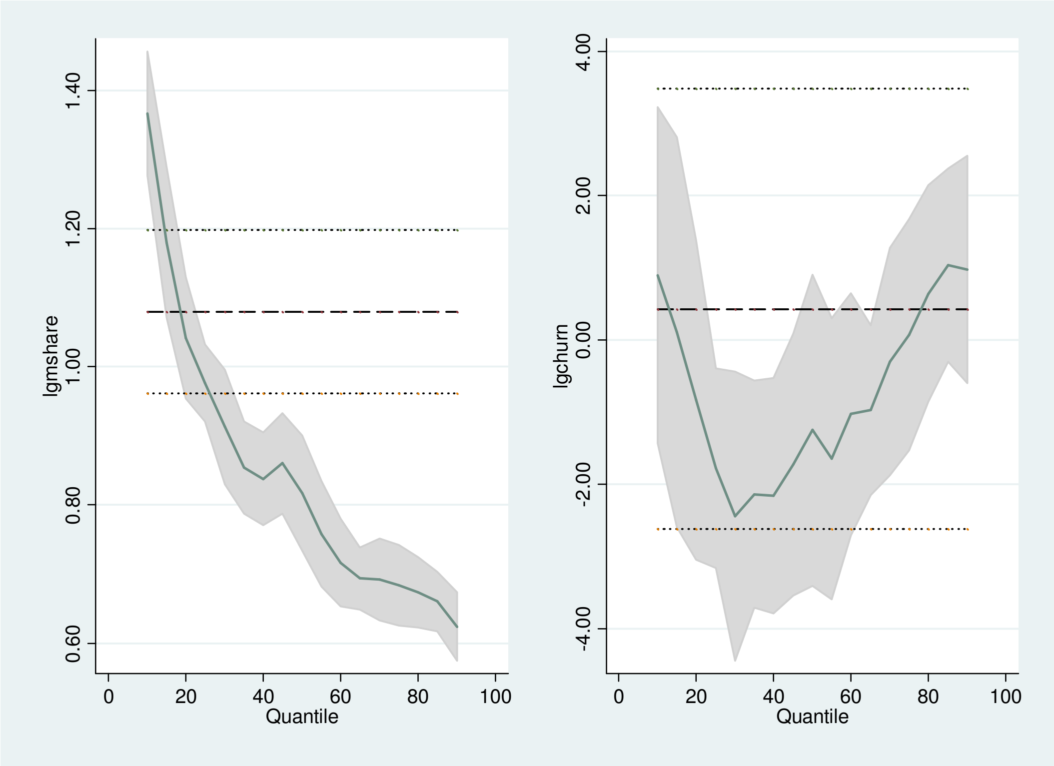


Figure 5: Quantile Regression

Dependent variable: ebitdamg (Eurozone sub-sample)



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