INSEAD

Faculty & Research

# Pricing Practices and Firms' Market Power in International Cellular Markets, An Empirical Study

by

D. Nunn

and

M. Sarvary

2004/16/MKT
(Revised Version of 2002/95/MKT)

Working Paper Series

# Pricing Practices and Firms' Market Power in International Cellular Markets, An Empirical Study

Dana Nunn

and

Miklos Sarvary*

Revised: February 2004

* Dana Nunn is a Senior Manager at Kana Communications, 740 Bay Road, Redwood City, CA 94063, dana@kana.com and Miklos Sarvary is Associate Professor of Marketing at INSEAD, Fontainebleau, France, miklos.sarvary@insead.edu.

# Pricing Practices and Firms' Market Power in International Cellular Markets, An Empirical Study


## Abstract

Previous studies on international marketing have typically asked the question: "how is the demand characterized across countries?" Such analysis is then used to provide guidelines for firms to enter new markets and/or to allocate marketing resources across countries. In order to provide such normative guidelines however, one also needs to analyze the supply-side of the problem, i.e. ask: "what is the likely market power that firms will be able to command in different countries?" Building on the New Empirical Industrial Organization (NEIO) framework, recent research in marketing provides marketers with a variety of tools to explore competitive interactions among firms in the context of a single market. The goal of this paper is to extend this literature to a multi-market/multi-national context, thereby helping international marketers estimate the likely market power they may face when entering new countries. We illustrate the proposed methodology on the mobile telecommunications industry, using price and quantity data from 10 countries around the world, estimating market power as a function of a number of country characteristics.

The results indicate that, while the simple presence of competition diminishes firms' market power, higher number of competitors in a country does not have significant incremental effect. In contrast the severity of anti-trust policy in the country has a significant negative effect, while the monopolist's lead-time before competition is allowed has a significant positive effect on market power. These results suggest that market power in different countries may partly originate from collusive pricing among cellular operators as well as from consumers' switching costs across service providers. For international marketers the findings imply that the attractiveness of wealthier countries (with usually faster diffusion rates and larger market potential) may be mitigated by higher levels of competition (as a result of developed anti-trust regulation and more consumer exposure to competitive marketing practices). From a policy point of view it suggests that (in contrast to the conventional wisdom) simple deregulation may not be enough to reduce prices to competitive levels. In addition, a severe anti-trust policy is crucial to achieve this goal.

## 1. INTRODUCTION

Previous research in international and global marketing has put considerable emphasis in recent years on studying how new products/innovations diffuse across the globe and how country characteristics affect such diffusion patterns (see Dekimpe et al. 2000a for an extensive review). The underlying idea is that understanding the cross-country diffusion process may help global marketing managers in designing entry strategies (i.e. selecting attractive markets) and/or allocating marketing resources across countries. While considerable progress has been achieved in understanding global diffusion patterns, the international marketing literature has mostly focused on the demand-side, typically neglecting the supply-side of the analysis. In particular, no study to our knowledge provides guidelines on how to assess the likely market power of firms in different countries or their ability to extract value from a given marketplace. Clearly, as the level of competition has a major impact on firm profitability, it is important for international marketers to understand how country (i.e. market) characteristics are likely to affect competition and firms' market power. To illustrate this problem, imagine for example, that a country is very receptive to an innovation, i.e. it has high market potential and is forecasted to have a fast within-country diffusion process. A priori, this country could be a good target for a firm willing to become international. However, if one is to expect fierce price competition among industry players, then the country is less attractive than what a simple demand analysis would suggest. In sum, supply-side analysis *together* with an understanding of the demand conditions provides a more complete picture on market evolution and is more likely to generate successful international marketing strategies.[1]

This neglect of supply-side analysis in the international context is quite surprising in light of the relatively large marketing literature on the topic in a single market environment. In recent years, New Empirical Industrial Organization (NEIO) models (see, Bresnahan 1989) have gained considerable ground in marketing and were used to study a variety of issues related to competition and in a variety of contexts. For example, Kadiyali, et. al. (1996) study competitive product line pricing in the laundry detergent market and show that firms position their strong brands as Stackelberg leaders with their rival's minor brand being the follower.

[1] A similar argument has been advanced recently by Cotterill, Putsis and Dhar (1999) in the context of private label brands and by Villas-Boas and Winer (1999) in the context of consumer brand choice.

Using data from a large variety of FMCG categories, Cotterill et. al. (1999) show that the competitive interactions between national and private label brands are asymmetric in favor of national brands (see also Kim and Parker 1999 on the collusive conduct in private label markets). In the context of the U.S. yogurt market Kadiyali, et. al. (1999) show that line extensions may be a way for firms to increase their market power. Manufacturer-retailer interactions and channel power are explored in Kadiyali, et. al. (2000) for the markets of refrigerated juice and tuna. Vilcassim et. al. (1999) study the dynamic pricing and advertising of competing firms in the personal care products category and find that while firms compete in advertising, their pricing is cooperative. Finally, in a recent paper, Sudhir et. al. (2003) explore time-varying competition in the U.S. photographic film industry. For a comprehensive recent review of this growing marketing literature, see Kadiyali, et. al. (2001).[2]

The primary goal of this paper is to marry the above two literature streams and propose a simple methodology to estimate the market power of competing firms across countries for a given industry by linking market power to a number of country (market) characteristics. As mentioned above, such methodology is useful in assessing and comparing the level of competition across countries and therefore, provides a tool for international marketers to generate normative insights. The method may also serve regulators who seek to understand what country characteristics may lead to higher levels of competition in the market. Second, in the context of cellular communications services, the paper seeks to illustrate the method by making a modest attempt at generating substantive insights with respect to the effect of market factors (country characteristics) on firms' pricing power. We assess the effect of four relevant factors: (i) number of competing firms in the country, (ii) severity of the country's anti-trust policy, (iii) the monopolist's lead-time before competition is introduced and (iv) market growth rates. From the perspective of decision makers (managers and policy makers), this analysis can provide useful insight with respect to questions such as:

- Which countries (markets) are more likely to result in oligopolies where firms market power is high?

[2] See also, Dube, et. al. (2002) for a summary of the literature on the structural applications of discrete choice models.

- What are the potential reasons for this market power? In the context of cellular services, does market power result from limited number of competitors, switching costs or consumer loyalty, high market growth or the lack of a severe anti-trust policy?
- Is deregulation (i.e. allowing for competitive entry) sufficient to ensure competitive pricing by firms?

The international context and the cellular service category provide a unique setup to address these questions. In essence, this multi-country setup can be viewed as a repeated experiment in which each country represents an observation with a particular market outcome (firms' market power) and a particular set of exogenous market (country) characteristics, which may explain this outcome. The product category is also compelling for a number of reasons. Offerings are public knowledge, services are perfectly mobile, competing products/services can be considered relatively homogeneous, i.e. while switching costs exist they do not prevent consumers from moving between service providers. The data we use originate from the International Telecommunications Union (ITU), which reports cellular prices, total number of subscribers (industry output) and telecommunication costs for several countries between 1980 and 1997. This time period corresponds to a relatively stable growth of the mobile telecommunications industry marked by a general tendency for deregulation (introduction of competition) in most countries. Furthermore, the time period precedes the drastic structural change in the industry at the turn of the millennium resulting from the combination of several factors, including the 3G-fiasco, the general tech-downturn and the recent massive migration of all telecom and Internet services on mobile handsets. Combined with data on country (i.e. market) characteristics (e.g. number of competitors, market growth rates, anti-trust policy, etc.), allows us to measure the effect and relative importance of market factors on firms' competitive pricing behavior and the resulting market power. To do so, we extend the standard structural model of competition (Bresnahan 1989) that simultaneously estimates supply, demand, and "conduct" (market power) by incorporating country-specific covariates in the conduct parameter (see e.g. Parker and Roller, 1997 for a similar approach in a multi-market duopoly context within the U.S.).

Our empirical findings suggest that, *on average*, cellular prices in international markets where competition has been introduced, while lower than under monopoly, are significantly higher than competitive levels. The market power of firms seems to be strongly influenced by two variables: the severity of the country's anti-trust regulation, and the length of the monopoly period before competition is introduced. As expected, the first factor decreases market power while the second one significantly increases it. Interestingly, the number of competitors and market growth rates do not significantly impact the level of market power. These findings suggest that firms' market power may originate from the combination of two factors: (i) collusive pricing behavior where firms find ways to coordinate on higher than competitive prices and (ii) consumer switching costs. The results have important implications for global marketers whose goal is to identify profitable international markets as well as for policy makers trying to protect consumer interest by promoting lower prices.

The paper is structured as follows. The next section describes the industry context and the research design. Section 3 introduces the proposed empirical model and its particular implementation in the international cellular context. Section 4 describes the data and presents the calibration/validation of the specification. The empirical findings are reported in Section 5, and the paper ends with a discussion of the results and concluding remarks.

## 2. INDUSTRY CONTEXT AND STUDY DESIGN

In the past two decades, cellular telephone technology has rapidly diffused into local markets throughout the globe. This growth is expected to continue, if not increase, in the coming years. In a special report on wireless technology, *Business Week* (October, 20, 2003) reports that in 2003, the number of worldwide wireless subscribers reached almost 1.3 billion, surpassing for the first time fixed line subscriptions: Verizon Communications' CEO claims that "wireless is redefining telecom" (*Business Week*, October 20, 2003).

The market power of mobile service providers has been a controversial topic. Largely due to the fact that this industry has always figured in the collimator of regulators many countries have been confronted with the issue of how to promote the development of these markets and protect consumers' interest. Based on the general US experience in a variety of industries, the conventional wisdom at the beginning of the 1990s was that simple deregulation (i.e. allowing competitive entry) is usually a solution to the above problem. In the telecommunications sector in particular, there has been a significant worldwide trend toward deregulation in the last two decades. This conventional view is reflected, for example in the following quote from *The Economist*:

> "The best-developed markets for the new [cellular] telephony are those where two or more operators opened up the market in competition. In countries like America, Britain and Sweden, which all introduced competition in the early-to-middle 1980s, more than 2% of the population have mobile telephones. In equally rich Germany, Italy and Spain, whose second operators have yet to launch, the figures are not half as high." *The Economist*, May 30, 1992.

Deregulation is not universal however, and monopolies in cellular services have persisted in some countries or geographic regions. For example, in Malaysia the government has pursued a competitive market structure in order to increase business opportunities (Mesher and Zajac 1997). By 1996, six firms operated cellular systems in Malaysia and the market is characterized by low rates and high demand. In Switzerland, by contrast, Swiss Telecom remained a monopolist in cellular services till the mid-1990s. More recent evidence further questions the effectiveness of simple deregulation in reducing firms' pricing power. In France, for example, competition has been allowed in cellular markets, but the technology has had disappointing penetration rates compared to other European countries due to the persistence of high prices. Another controversial example is the United States itself, where in order to stimulate competition, the Federal Communications Commission (FCC) has subdivided the country to some 300 non-overlapping markets (SMSAs) and imposed a duopoly in each. Parker and Roller (1997) show that there was considerable variation in prices across these "independent" markets, with prices sometimes being well above competitive levels. The authors suggest that firms may collude in some cellular markets, which is supported by the finding that market power was found to be significantly higher under multi-market contact and the cross-ownership of cellular operators.[3] Current evidence on margins tells a similar story. While there is consensus about rising competition in the cellular industry, wireless margins increased from 31% to 33% in the last year alone (*Business Week*, Oct. 20, 2003. p.63).

This debate and the variance of experiences across countries suggest that simple heuristics (e.g. whether the government allows competitive entry or not) are not enough to estimate the

[3] Jain et al. (1999) provide a demand-side explanation for the evolution of prices in the U.S. Their model is based on consumer heterogeneity in price sensitivity, although it also assumes non-competitive pricing behavior where firms use trigger strategies in a repeated game.

likely pricing power of firms. Market power may come from a number of different sources that may be specific to the industry in question. To address this challenge, we propose a simple methodology by adapting existing NEIO models to the multi-national context. Our approach is similar to Parker and Roller (1997) in that we make the conduct parameter a function of country (market) characteristics. Rather than comparing firm behavior across markets *within a single country*, where some market characteristics (e.g. the anti-trust environment) are constant, our approach compares firm behavior *across countries* having *different* environments or market characteristics. We also let the number of competitors vary across markets and measure the effect of this variable on firms' pricing behavior. This allows us to answer a separate set of questions than the ones addressed by previous research. Beyond useful insights to practitioners the empirical investigation can also generate interesting hypotheses for micro-economic theory.

The fact that the repeated market experiment is across countries raises a number of challenges. As international marketers are well aware of, cross-country data are scarce, incomplete and often does not provide the level of detail that empirical researchers are used to in a single country setting. For example, our data does not contain firms' individual outputs and prices; only "the" market price and aggregate output is available in each country. Furthermore, to perform proper cross-country comparisons the data needs to be comparable across countries, a concept called sample matching (Dekimpe et. al 2000a). This limits any analysis to countries or regions that represent a single market in the sense that a single market price and corresponding aggregate industry output can be unambiguously defined. This excludes countries for example, where there is substantial heterogeneity across competitors either in market coverage or costs. The International Telecommunications Union's (ITU) data set reports prices, subscriber figures and costs only for those countries and time periods where such definitions are possible. As such, most countries (even with developed cellular markets such as the United States) could not be used in our study because a single market price could not be defined. This leaves us with 10 comparable countries, which nevertheless represent enough variation in market structures to perform useful comparisons. Table 1 describes the key market characteristics of all the 19 countries that were included in the study. Only 10 of these countries (those where the maximum number of competitors is higher than 1) exhibit competitive pricing behavior.

One aspect of the above institutional context makes it particularly suitable for studying the effect of market characteristics on firms' market power, namely that many countries introduced cellular systems in a monopoly setting with competitors entering only after a few years. In some countries (e.g. Belgium, Finland, Singapore) monopolies still prevailed at the end of the observation window. These monopoly observations provide a unique opportunity to calibrate the demand and supply in the model. As firm behavior (i.e. monopoly pricing[4]) is known in these situations, one can test the validity of the supply and demand equations, which is critical because we do not have direct information on firms' marginal costs. If under monopoly periods, the model predicts the expected (monopoly) pricing behavior, we can trust the demand and supply specifications.

In our study, market power varies across countries as a function of market characteristics. In particular, we look at the effect of four factors, assumed to be relevant in influencing competing firms' market power: (i) the number of competitors in the country, (ii) the monopolist's lead-time before competition was allowed, (iii) the severity of the country's antitrust policy and (iv) the growth rate of the cellular market within the country. The choice of these factors represents a compromise between possible drivers of firm behavioral and data availability for the maximum number of countries. Table 1 describes these variables for the countries studied. We expect that the number of competitors and the severity of the country's antitrust policy will reduce firms' market power. It is broadly accepted that both of these factors contribute to increased competition and lower prices. In contrast, we expect higher market growth rates and a longer lead-time by the monopolist to increase firms' market power. Steady market growth has been argued to provide incentive for competing firms to collude (see Tirole 1988, chapter 6) while the monopolist's lead-time – if leading to higher market power – could be argued to indicate the existence of switching costs for consumers. In what follows, we present a model to analyze this international cellular dataset.

---

[4] We assume that monopolists do not engage in preemptive pricing to deter the entry of competitors. The data support this assumption in two ways. First, in most countries entry has eventually occurred, i.e. such practices if ever used were not feasible. Second, in the Appendix, we present an analysis of the sequence of prices over time and conclude that limit pricing behavior – if at all present – has virtually no effect on our substantive results because it may affect only an insignificant number of observations.

## 3. EMPIRICAL MODEL OF INTERNATIONAL CELLULAR MARKETS

We wish to estimate a structural model of oligopolistic competition in cellular telephone markets, where we define "market" as a country. We start with the standard conjectural variations equation proposed by Bresnahan (1989):

$$\lambda \frac{\partial p_{tc}(Q_{tc}, Z_{tc})}{\partial q_{itc}} q_{itc} + p_{tc}(Q_{tc}, Z_{tc}) - MC(q_{itc}, w_{tc}) = 0\,, \qquad (1)$$

where $c$ indicates the country, $t$ indicates the time period and $i$ indicates the firm. $Q_{tc}$ is the aggregate quantity produced in the market (country), $Q_{tc} = \Sigma_{i=1}^{N_{tc}} q_{itc}$, where $q_{itc}$ is firm $i$'s output and $N_{tc}$ is the total number of firms in the market. $Z_{tc}$ is a vector of exogenous market factors that affect the demand, denoted by $p_{tc}\,(Q_{tc}, Z_{tc})$. $Z_{tc}$ includes factors such as population, GNP/capita, time, the number of landline phones in the country, and the level of urbanization. $MC(q_{itc}, w_{tc})$ is firm $i$'s marginal cost which is a function of the individual firm's output, $q_{itc}$ as well as market factors, $w_{tc}$, including wages, electricity prices, capital costs, and operating expenses. In the conjectural variations model, different values of $\lambda$ generate a wide range of competitive outcomes: if $\lambda$=0 then price equals marginal cost, i.e. the industry can be considered perfectly competitive. If $\lambda$=$N$, then prices are set at monopoly or cartel levels (marginal costs equal marginal revenues). Finally, the Cournot-Nash equilibrium is embedded in the model at $\lambda$=1.

Our data are aggregated for price and quantity at the industry level.[5] As in Parker and Roller (1997), we assume that in any given market, individual firms' marginal costs, are identical,[6] and we therefore sum (1) over firms and divide by $N_{tc}$ to obtain:

$$\theta \frac{\partial p_{tc}(Q_{tc}, Z_{tc})}{\partial Q_{tc}} Q_{tc} + p_{tc}(Q_{tc}, Z_{tc}) - MC(Q_{tc} / N_{tc}, w_{tc}) = 0\,. \qquad (2)$$

[5] The model can be easily adapted to the case where individual firms' market shares and prices are also available.

[6] This is a safe assumption in our context as we expect most variation in marginal costs across countries rather than within a country. The results also support this assumption as no scale economies in marginal costs are detected empirically.

Our variable of interest is $\theta=\lambda/N$ that we define as the measure of market power. Corts (1999) shows that this parameter can be interpreted as an "elasticity-adjusted Lerner index" (p.231). In this interpretation, market power can result either from an inelastic demand structure (e.g. differentiated firms or switching costs) or from firms' collusive behavior. Note that $\theta=1$ indicates monopoly or cartel pricing (marginal revenue equals marginal cost), $\theta=0$ is marginal-cost pricing (perfect competition), and $\theta=1/N$ is consistent with Cournot-Nash pricing. Corts (1999) draws attention to the fact that by combining two factors (demand elasticity and firms' conduct) this measure may not detect/measure accurately firms' market power (see also Lau 1982). However, he also shows that this problem arises only when the demand is highly varying across time periods (e.g. in the case of strong seasonal demand). The more persistent are trends in the demand the less this constitutes a problem (see also the discussion in Kadiyali et. al. 2001, p. 170). In our case, for all countries there is a consistent growth trend and there are no demand fluctuations.

Clearly, in our model, $\theta$ should vary across countries to allow possible differences in demand structures and conduct. Thus, we define it as a function of market characteristics:

$$\theta_{tc} = \theta(\mu_{tc}), \qquad (3)$$

where $\mu_{tc}$ includes market factors such as the number of competitors, level of antitrust regulation, the growth rate of the country's cellular telephone market and the monopolist's lead-time before the entry of the first competitor. Beyond allowing market power to vary across countries, these factors may also inform us about the origins of this market power.

The empirical implementation of $Z_{tc}$ and $w_{tc}$ needs to be specified to obtain sound structural supply and demand models of the variation in price and quantity across time and across countries. Kadiyali et. al. (2001) warn that "functional forms of demand and cost need to be carefully considered in models that use conduct parameter estimation procedure". As mentioned earlier, this is especially important because we do not have direct information about firms' cost structures. We have chosen a semi-logarithmic functional form for the demand while keeping a linear form for the marginal cost function. We have done so for two reasons. First, in doing so we followed Parker and Roller (1997) who used this specification with success in the context of the U.S. cellular industry. Second we wanted to ensure a minimum level of non-linearity in the model. Bresnahan (1989) discusses appropriate functional forms in conjectural variation models addressing the identification problems raised by Lau (1982) and concludes that this minimum level of non-linearity is required for the correct identification of the conduct parameter (see also Kadiyali et. al. 2001, p. 174). Fortunately, beyond the above arguments, we can also test (or calibrate) the specification of the model using the monopoly period observations, where conduct and the resulting market power is assumed to be known (i.e. $\theta$=1). If the model predicts monopoly behavior in monopoly periods, we can be more confident in the model specification (see section 4.3).

Thus, demand is specified as:

$$p_{tc} = \eta_0 + \eta_1 \log(Q_{tc}) + \eta_2 \log(\mathrm{POP}_c) + \eta_3 \mathrm{TIME}_c + \eta_4 \log(\mathrm{GNP}_c) + \eta_5 \log(\mathrm{PHONES}_c) + \eta_6 \mathrm{URBAN}_c + \varepsilon_1. \quad (4)$$

where, $p_{tc}$ is price defined as the average monthly cellular bill excluding equipment costs and $Q_{tc}$ is the number of cellular telephone subscribers in country $c$ at time $t$. $\mathrm{POP}_c$ is the population of the country, which is used to explain demand differences due to large market size differences across countries. $\mathrm{TIME}_c$ is a country specific time trend variable, which is used as a proxy to capture exogenous diffusion trends. $\mathrm{GNP}_c$ is the GNP per capita in each country measured in constant US dollars, which indicates the relative wealth of potential consumers and impacts their willingness (or ability) to pay for cellular service. $\mathrm{PHONES}_c$ is the number of landline telephones in the country, which controls for network externalities: the usefulness of the cellular phone will depend upon the number of landline phone customers that a subscriber can contact using his/her cellular telephone. $\mathrm{URBAN}_c$ measures the urbanization level of the country (percent of the population living in urban areas). Since cellular telephones are most useful in metropolitan areas where cell density is high, urbanization should increase the demand for cellular service in a country. We will discuss these variables in more detail in the next section.

The marginal cost function is specified using the following linear equation:

$$MC_{tc}=\gamma_0+\gamma_1(Q_{tc}/\mathrm{COMP}_{tc})+ \gamma_2\mathrm{ENERGY}_c+\gamma_3\mathrm{LEND}_c+\gamma_4\mathrm{WAGES}_c+\gamma_5\mathrm{OPCOST}_c. \quad (5)$$

$COMP_{tc}$ is the number of cellular operators in country $c$ at time $t$, $ENERGY_c$ is an index of electricity prices across countries, $LEND_c$ is the market lending rate, $WAGES_c$ measures the average monthly wage of workers in the country, and $OPCOST_c$ is the operating cost of the telecommunications network in the country. Ideally, we would like to have the operating costs of the cellular telephone networks, but this data was not available for most countries. $OPCOST_c$ was used as the closest proxy. Notice that we do not have actual data on marginal costs, so equation (5) cannot be estimated on its own. However, in our model, data on marginal costs are not required since we estimate:

$$p_{tc} - MC_{tc} + \theta_{tc}\eta_1 + \varepsilon_2 = 0. \qquad (6)$$

In a first step, we will estimate a single $\theta$ across all markets, to measure an "*average*" pricing behavior across countries. By substituting equation (5) for marginal cost, we then need to simultaneously estimate demand (4) and supply (6) using the aggregate (pooled) data on $p_{tc}$, $Q_{tc}$, $Z_{tc}$, and $w_c$.

In the next step, we allow $\theta$ to vary across countries. To do so, we model $\theta$ as a function of market characteristics, $\mu_{tc}$, which are assumed to impact firms' pricing behavior:

$$\theta_{tc} = \beta_0 + \beta_1 COMP_{tc} + \beta_2 POLICY_c + \beta_3 GROWTH_{tc} + \beta_4 LEAD_c, \qquad (7)$$

where $LEAD_c$ is the number of years that the first market entrant enjoyed a monopoly prior to competitive entry (if applicable). $POLICY_c$ is an indicator of anti-trust regulatory power in the country measured on a 7-point scale (1=low, 7=high). Finally, $GROWTH_{tc}$ is the cumulative growth rate of the cellular telephone industry since introduction. More detail on these variables is presented in the next section. For this, second step of the model estimation we simultaneously estimate demand (4) and supply (6) substituting (5) and (7). This ensures consistent parameter estimates, including estimates of the impact of market characteristics on $\theta$, the parameter for market power.

## 4. DATA, PRELIMINARY ANALYSIS AND CALIBRATION

### 4.1 Data and Summary Statistics

As global marketers are well aware of, data availability is a challenge in international research and often requires the combination of multiple sources. Our price and quantity data come from the International Telecommunications Union (ITU) between 1980 and 1997. Price has been defined as the average monthly bill excluding equipment costs. An average bill includes 500 minutes of usage in addition to a monthly subscription charge. While average usage levels are certain to differ across countries, we must compare the prices of equivalent products. Prices include both digital and analog rates, weighted based on the share of subscribers in each technology. The 500 minutes of average usage is based on findings in Parker and Roller (1997) on usage levels in the U.S. cellular telephone markets. Quantity is simply measured as the number of cellular subscribers and includes both digital and analog users. The demand-side variables – the population of the country ($POP_c$), time ($TIME_c$), GNP per capita ($GNP_c$), the number of landline telephones in the country ($PHONES_c$) and the urbanization level ($URBAN_c$) – were all available from Euromonitor and refer to the end of the observation window.[7] GNP is measured in constant US dollars and URBAN as a percent of the population living in urban areas. Summary statistics are presented in Tables 2a-2c.

On the supply-side $ENERGY_c$, the index of electricity prices across countries was collected from the International Energy Association, $LEND_c$, the market lending rate and $WAGES_c$, the average monthly wage of workers in the country were both available from the International Financial Statistics and $OPCOST_c$, the operating cost of the telecommunications network in the country is available from ITU. Summary statistics for the supply-side variables are also reported in Tables 2a-2c.

Variables affecting market power, $\theta_{tc}$ also originate from multiple sources. $COMP_{tc}$, the number of cellular telephone companies operating in country *c* at time *t* was made available by the Strategic Group Inc. $LEAD_c$, the number of years that the first market entrant enjoyed a monopoly prior to competitive entry (if applicable) is available from ITU. $POLICY_c$, the index of anti-trust regulatory power in the country was developed specifically for this study using expert judges based on "Investing, Licensing, & Trading" (ILT), a publication by The Economist Intelligence Unit, part of the group, which publishes *The Economist*. ILT provides detailed description of anti-trust regulation in numerous countries around the world. Three

[7] This choice ensured maximum data availability and, since within-country variations of these variables were negligible compared to variations across countries the results are virtually unaffected by it.

highly qualified, independent judges were asked to use this publication to develop a Market Policy Profile for each country, coding 25 different measures on a scale from 1 (loose anti-trust policy, e.g. Hong Kong) to 7 (strong anti-trust policy, e.g. the United States).[8] The measure most relevant to the present study was the overall level of government laws to promote competition. Inter-judge agreement was found to be very high (Cronbach alpha = 0.90), on this measure, which was used to indicate the ability of regulators to prevent collusion and encourage free-market competition among firms in the country. Finally, $\text{GROWTH}_{tc}$, the cumulative growth rate of the cellular telephone industry since introduction was constructed from output data as: $(Q_t - Q_I)/Q_I(t - I)$, where $I$ indicates the year of introduction of cellular technology in that country. Measures for these market characteristics for all countries are available in Table 1.

### 4.2 Preliminary Analysis

Simple correlation analysis presented in Table 3 reveals that among the variables expected to influence conduct only the number of competitors (COMP) correlates with quantity. Clearly, this analysis provides limited insight. Table 3 also, shows that – as usually the case in international research – GNP per capita is correlated with other economic and demographic variables (see, e.g. Dekimpe et. al 2000a). Interestingly population size (POP) is also correlated to many supply-drivers. None of these correlations are very high, however. Only four correlations exceed 0.6 and only one (between ENERGY and PHONES) exceeds 0.8. Multi-collinearity therefore, does not seem to be a serious problem.

We also ran a simple OLS analysis on price and quantity using, first, all independent variables and second, TIME and all country-specific dummy variables. This analysis is available in the Appendix. The R-squares of the regression with TIME and the country dummies is 0.92 on price and 0.74 on quantity, with most country dummies significant while TIME being significant for quantity only (not price) reflecting general market growth (diffusion).[9] The regressions of all independent variables on price and quantity have R-squares of 0.75 and 0.76, respectively. COMP and LEAD are significant in the regression on price both having

[8] The judges were 3rd year Ph.D. students in economics without knowledge of the study's purpose. To ensure the reliability of the scales, the measures were developed on 60 countries not just the 10 countries included in the analysis. The extremes of the scale were anchored to Hong Kong (1) and the United States (7).

[9] That prices vary a lot more across countries than over time is important given the strong diffusion process of cellular services across countries. It implies that we can assume a single demand structure for each country in the observation window as diffusion is not driven by price decrease.

negative signs. In general, this analysis reveals that price and quantity vary significantly with the independent variables and across countries and that the independent variables pick up roughly the same amount of variation in the data than country dummies. Beyond this general insight, one can say little about these results as they blend together supply and demand drivers and do not distinguish between competitive and monopoly periods. A more accurate validation exercise, taking the above factors into account is presented next.

**4.3 Model Calibration on Monopoly Periods**

We verify the specification of the supply and demand equations using the monopoly observations in the data set. There are numerous countries and time periods for which markets operate under a monopolist. For these time periods, $\theta$ is naturally supposed to be equal to one. Therefore, we can estimate the model using only the monopoly observations and test whether $\theta$ is statistically different from one. If not, the model is assumed to be correctly specified. In our data set, there are 64 observations across 16 different countries, which have price and quantity set by a monopolist.[10] We estimated equations (4) and (6) simultaneously only on these observations using non-linear three-stage least squares (3SLS) estimation. The results are reported in Table 4. On the demand-side, the estimate on log($Q$) is highly significant and negative, as expected. The parameter estimate implies price elasticities across countries ranging from –0.32 (Singapore) to –3.71 (Poland). Differences across countries in price elasticity (see details in the Appendix) are driven by differences in price, with higher prices meaning higher elasticities in absolute value, i.e., as expected, higher consumer sensitivity to price at higher price levels. In terms of the demand drivers, TIME is found to be significant with a positive coefficient, actually indicating increasing prices. URBAN is also significant, as expected and consistently with previous research on international cellular markets (see Dekimpe et. al. 1998). GNP is not significant in this model although the parameter has the right sign. This may be because GNP is highly correlated with a number of other demand drivers, namely URBAN. Also, it is worth to note that in the subsequent competitive models with the same demand specification the parameter estimate on GNP is significant. Interestingly PHONES is not significant implying that network effects related to the size of the landline network are not relevant. It is also possible that in some, less developed countries cellular phones are substitutes for the landline phones, i.e. people purchase them because they

[10] In Ecuador, cellular service was introduced in a duopoly; in Malaysia and Thailand, we do not have price and quantity data for the monopoly period.

are unable to obtain a regular phone due to the poor communication infrastructure. This effect may mitigate the network effect of landline phones. Finally, population size (POP) is marginally significant.

On the supply-side, quantity is not significant, indicating the absence of scale economies for marginal costs. This is important because this assumption was needed for the aggregation of within-market demand across firms in the model. ENERGY, LEND and OPCOST all have significant coefficients, while the one for WAGES is insignificant. The latter is not surprising as cellular services are not labor intensive. On the contrary, ENERGY and OPCOST having negative effects on marginal costs is unexpected. It is possible that these variables do not directly influence marginal costs but rather measure the general infrastructure in the country, in this way, indicating a lower marginal cost at higher levels. LEND has a strong positive effect, which has strong face validity as the lending rate is a good measure for the cost of financing cellular equipment, a common practice in the cellular industry (see also Parker and Roller 1997). Finally, and most importantly, with respect to market power, the estimate of $\theta$ is 1.27 with a standard error of 0.4337, which is statistically significantly different from zero ($t$=2.93) but not from one ($t$=0.63). Clearly, the expected monopoly pricing behavior is supported by the data in this specification.

In summary, since demand and supply parameters have plausible estimates and the model produces the expected estimate of $\theta$ in the monopoly periods, we therefore conclude that the specification of the demand and supply equations is appropriate.[11] Given the above result, in subsequent model estimations, we will restrict $\theta$ to equal 1 in monopoly periods in order to increase the efficiency of our estimates for $\theta$ corresponding to competitive time periods. In a validation exercise, we also estimated the models without this constraint and found similar results (details are available in the Appendix). Specifically, the same demand and supply drivers and the same variables driving $\theta$ were found significant in the analysis without the constraint.

## 5. EMPIRICAL RESULTS

### 5.1 Average $\theta$ Analysis

First, we estimate the average $\theta$ in non-monopoly periods. Our data is both cross-sectional as well as time-series in nature, but we do not have enough observations per country to obtain a reliable estimate for $\theta$ in each country. We pool the data across countries and estimate an "average" $\theta$ across non-monopoly periods to obtain a general idea on firms' market power compared to the benchmark values of $\theta = 0$ (perfect competition) and $\theta = 1$ (monopoly pricing). We are not suggesting that cellular telephone pricing strategies are the same across countries. However, we do want to get a sense of the degree of market power overall in order to determine if it is interesting at all to model it as a function of market characteristics. If the average $\theta$ is found to be significantly higher than the competitive level then we estimate the more realistic case, in which markets in different countries are allowed to vary in the level of firms' market power based on the number of competitors, anti-trust regulation, market growth and the monopolist's lead-time.

In the data set, there are 10 different countries for which, at some point in time during the observation window, an oligopolistic cellular market exists. These countries represent 56 observations in total, with 16 monopoly and 40 oligopoly observations. We estimate equations (4) and (6) simultaneously substituting (5) for all these observations, again using non-linear 3SLS, where we restrict $\theta$ in the 16 monopoly observations to be equal to one. The estimate for $\theta$ therefore reflects the average degree of market power across countries and time periods in which more than one cellular company was operating.

The results from the estimation of this model are given in Table 5. The supply and demand variables have parameters that are similar to the estimates in the calibration (monopoly observations only) model, with GNP now significantly positive in the demand equation. Price elasticities are also in the same range as for the calibration model (3 are somewhat smaller, 3 somewhat higher and 6 comparable – details are in the Appendix). While the estimate on $\log(Q)$ is smaller in absolute value, implying higher elasticities, prices are lower in competitive periods than under monopoly periods resulting in roughly equal elasticity values.

[11] We have run other specifications using different functional forms for demand and supply but those were unable to replicate monopoly pricing behavior for the monopoly observations and usually resulted in estimates with no face validity.

The average number of firms, across countries, operating in the non-monopoly time periods is 2.14. The estimate of $\theta$ is 0.72 with a standard error of 0.2726. This estimate is statistically different from zero ($t$=2.64) but not from 1 ($t$=-1.03) or from $1/N$=0.4673 ($t$=0.92). This indicates that while entry in the cellular telephone industry tends to bring prices down from monopoly levels, prices are significantly higher than they would be under perfect price competition. In sum, even under competition, on average firms have a significant level of market power. Next, we explore the origins of market power modeling $\theta$ as a function of regulatory policy, market growth, the number of competitors and the monopolist's lead-time.

### 5.2 Full Model with $\theta$ Varying Across Countries

As discussed previously, we estimate equations (4) and (6) simultaneously substituting (5) and (7), again restricting $\theta$ to equal one in monopoly periods. The results are provided in Table 6. Again, generally the same supply and demand parameters are significant with the same signs as in the two previous models (GNP remains significant in the demand). The estimate for log($Q$) is lower than in the "average-$\theta$" model, implying slightly higher price elasticities in absolute value. Elasticities range from –0.27 (Malaysia) to –3.93 (Poland); details can be found in the Appendix.

Our primary interest here is in the variables we have used to model $\theta$: COMP, POLICY, GROWTH, and LEAD.[12] Surprisingly, the parameter estimate for the number of competitors (COMP) is not significant. While the presence of competition decreases prices, it seems that additional competitors do not have significant marginal effect on market power. In their study on U.S. cellular markets, Parker and Roller (1997) suggested that cooperative pricing may exist between firms because the FCC regulated the market to allow only duopolies in each, thereby allowing firms to easily coordinate their pricing strategies. Our finding contradicts this conclusion, as additional competitors do not seem to decrease firms' market power. Our result is limited however, because we have very few countries with more than two competitors (remember the average number of firms in the competitive dataset is 2.14). Second, the parameter estimate on the monopolist's lead-time in the market (LEAD) is positive and significant. This suggests that market power may partially originate from the

[12] Individual estimates of market power for the 10 countries show significant variance but generally stay in the right range. In only two cases is $\theta$ significantly outside the theoretical range of [0; 1] (-0.75 for Finland and 4.91 for Poland – see details in the Appendix).

existence of consumer switching costs across cellular service providers.[13] In other words, even after new competitors have entered the market, consumers do not change their cellular provider in response to small price decreases. In return, firms tend not to decrease prices. Third, the parameter on GROWTH is *not* significant, failing to support the theory (Tirole, 1988) that, as the market grows faster, the larger future payoffs provide a stronger incentive for firms to practice collusive pricing. One explanation might be that market growth, although varying across countries, is very high in each country, which may result in a sealing effect. Finally, the last important result is that, as expected, the parameter on POLICY is significant and negative. It suggests that a stronger anti-trust environment is effective in significantly reducing firms' market power.

In summary, two substantive insights with respect to cellular markets seem to emerge from the empirical results: (i) competition reduces market power from monopoly levels but not significantly, and certainly not to perfectly competitive levels, (ii) two factors seem to explain firms market power in competitive markets, the existence of consumer switching costs and collusive pricing behavior by firms.

### 5.3 Validation with Alternative Models

To validate the model, we ran a number of alternative models. The details of the estimation results are available in the Appendix. First, we checked if the results change when $\theta$ is not restricted to 1 in the monopoly periods. The estimates remain virtually unchanged with the exception of WAGE, which becomes significantly negative in the supply equation. The estimates on the drivers of market power remain unchanged however. Second, we ran a fixed effects model to test the existence of demand and supply factors that are idiosyncratic to the individual markets (countries) and therefore would not be captured by our demand and supply variables. Unfortunately the scarcity of the data does not allow the introduction of a separate effect for each country. Instead, we created two dummy variables (for the supply and demand equations respectively), which capture if a country is developed or not.[14] The assumption was that the demand and/or supply might be qualitatively different in rich and poor countries. The results showed that this is not the case (details are available in the Appendix). Neither of the development dummy variables was significant and GNP lost significance indicating that the

[13] We would like to thank the reviewers for drawing our attention to this interpretation.

[14] These development dummies were generated based on a median split on GNP/capita.

supposed fixed effects do not exist (i.e. the development variables do not capture anything beyond GNP). Furthermore, our substantive results changed very little in the fixed effects model: while POLICY remained highly significant, the estimate on LEAD changed to marginally significant only. Third, we have also looked at the possible effect of market penetration. Again, the argument was that a significantly higher market penetration may mean different demand and supply conditions. The results indicate that this is not the case. The penetration variable was not significant in the model and the same variables driving market power (POLICY and LEAD) remained significant. We also ran the model with log(COMP) to verify if the reason for the lack of significance for the number of competitors comes from a non-linear effect of the variable. We found no change in the results and log(COMP) was not significant. Finally, we ran a model using a dummy variable for duopoly observations. Demand and supply estimates remained unchanged but the dummy variable had a significant negative coefficient, which suggests that the market power in duopolies is lower than in countries with multiple competitors. Clearly, the effect of the number competitors on market power requires further investigation. Overall, the estimation results of alternative models suggest that the qualitative findings of the model are robust.

## 6. DISCUSSION AND CONCLUSION

In this study, we presented an empirical model that allows the estimation of market power in a multi-market setting, by making market power a function of market characteristics. The model may provide a simple tool for international marketers to assess the competitive environment before deciding to enter new countries. We illustrated the model in the context of the international cellular telephone industry based on aggregate price and quantity data from 10 countries with comparable market structures. While our findings may be limited in many ways (see below), they seem to converge on two substantive insights with respect to the cellular industry. First, while competition reduces prices from monopoly levels, it leaves firms with significant market power; it certainly does not lead to perfectly competitive cellular markets. Second, two factors seem to explain firms market power in competitive cellular markets: consumer switching costs and collusive pricing across firms.

These results illustrate the practical importance of supply-side considerations for international marketing. Staying in the context of international cellular markets, our analysis shows that previous conclusions on how to select markets (countries) should be regarded with some reservation. In particular, previously published work on the same industry (see Dekimpe et al. 1998, 2000b) found that highly developed countries are more promising prospects for entry because of wealthier consumers and better infrastructures, resulting in fast penetration rates and high market potentials. Our study however, shows that in these countries, entrants are less likely to command high market power because competing firms are less likely to tacitly collude due to a more severe anti-trust regulatory environment.[15] Similarly, in developed countries, a more advanced distribution infrastructure (e.g. broader Internet availability or denser distribution networks) may reduce consumer search, as well as switching costs. On the flipside developed countries may also represent a more developed marketing environment that may generate higher consumer switching costs for consumers, mitigating the effect of the above two factors. In general, supply-side factors may have a major role in determining firm profitability across markets and therefore, such factors need to be taken into account when designing international marketing strategies. As such, the proposed methodology complements previously developed tools of demand-side analyses. In this respect, it is useful to mention that the model is easily extendable on many dimensions. First, it can be easily adapted to situations when more detailed data (on individual firms' prices and market shares are available). Second, it can easily incorporate other covariates that are judged to be relevant in determining firms' conduct (data availability is a well-known challenge in international marketing). Third, beyond the supply and demand drivers the model's structure is not specific to the cellular industry and allows a similar analysis in other – even very different - industries.

Our analysis has a number of important limitations. First, and most importantly, in our dataset, price and quantity data are only available at an aggregate level for each country. This resulted in the exclusion of many countries even with developed cellular markets (e.g. the U.S.) when these countries had multiple markets within the country with varying number of competitors in each. Furthermore, the aggregate nature of the data and the resulting empirical model do not allow for differences across firm behaviors. While our analysis suggests that scale economies are not important on the cost side, they may still result in different pricing behaviors across competitors in the same market (e.g. a larger firm may be more reluctant to introduce a price cut as it affects a larger customer base, than a smaller one). Similarly, our

[15] The finding that market power is highly affected by anti-trust regulation and not by the number of competitors may also be interesting for regulators and supports the growing sentiment that simple deregulation does not necessarily lead to competitive markets.

basic model specification assumes a homogenous product category, with no, or negligible differentiation across firms. Subsequently, our analysis challenges this assumption as the significant impact of the monopolist's lead-time on market power may indicate the existence of switching costs. The inability to explicitly account for firm differences clearly challenges the validity of the model. Second, as all international studies, ours also suffers from the lack of available variables across a large number of countries. This limited the number of variables we could include in the study, possibly resulting in omitted variables. This is mostly apparent in our estimates of the supply-equation. Ideally, one would like to have direct measures of marginal costs but such measures are rarely available and marginal costs need to be estimated indirectly. In our model, the only variable that convincingly captures marginal cost is the lending rate. While in this particular industry this is by and large the most important supply-driver, it would have been nice to include a larger set of variables driving firms' marginal cost. Unfortunately, we did not have such data available across markets. Similarly, for our main variable of interest, market power, we may have an omitted variable problem. Parker and Roller (1997) find, for example, that cross-ownership across cellular operators is an important predictor of cooperative pricing behavior. We did not have data to test this hypothesis in our international context, although it is likely that cross-ownership was present in some countries studied. Clearly, it would be useful to investigate the effect of additional country- or (market)-specific variables on firms' market power. Third and closely related to the above limitations, our study also suffers from a limited sample size. Again, this did not allow the specification of a proper fixed effects model, which would have allowed to us to capture country-specific idiosyncratic effects in the demand and/or the supply. Similarly, a larger sample would have allowed reliable estimates for the actual market power values in each country, in addition to estimates of the drivers of market power. Finally, the limited number of counties also poses a problem with respect to the generalizability of the results. While our countries represent large variability in terms of socio-economic development, demographics, culture and geographic location (which is generally an advantage in international studies that often use only developed nations), the set of countries only represents around 5-6% of the total number of nations in the world and an even smaller proportion in terms of the number of inhabitants. Furthermore, our country sample is biased towards smaller countries (as we could only use countries representing a single cellular market). As such, it is not clear that we can generalize our results to the remaining – especially large – countries.

In addition to addressing the above limitations, the paper suggests a number of additional extensions. First, our results only provide evidence in the context of a single industry. It is not clear, if one can generalize drivers of market power to other industries. Does such generalization depend on the similarity of industries? Similar studies on other industries would be definitely needed to test these hypotheses. Surely, such analyses would need to adjust for the demand and supply drivers of the industries in question. Finally, an important question is how to integrate the results of the demand- and supply-side analysis of international markets in a consistent statistical framework. We argued that both sides of the analysis are important because in many cases they would lead to contradicting normative guidelines. This raises the question: how to systematically integrate the - largely qualitative - insights gained from these two different perspectives and methodologies.

## REFERENCES


Bresnahan, Timothy F. (1989), "Empirical Studies in Industries with Market Power," in *Handbook of Industrial Organization*, Vol. II, 1011-1058.

*Business Week* (2003), "The Wireless Challenge", October 20, 46-63.

Corts, Kenneth S. (1999). "Conduct Parameters and the Measurement of Market Power," *Journal of Econometrics*, 88, 227-250.

Cotterill, W. Ronald, William P. Putsis Jr. and Ravi Dhar, (1999), "Assessing the Competitive Interaction between Private Labels and National Brands," *Journal of Business*, 73 (1), 109-37.

Dekimpe, M., P.M. Parker and M. Sarvary (1998), "Staged Estimation of International Diffusion Models: An Application to Global Cellular Telephone Adoption," *Technological Forecasting and Social Change*, 57, 105-132.

Dekimpe, Marnik G., Philip M. Parker and Miklos Sarvary (2000a), "Multi-Market and Global Diffusion", in "*New Product Diffusion Models*", Mahajan, Muller and Wind eds., Kluwer Academic Publishers, 49-73.

Dekimpe, M., P.M. Parker and M. Sarvary (2000b), "Globalization: Modeling Technology Adoption Timing Across Countries", *Technological Forecasting and Social Change*, 63, 25-42

Dube, Jean-Pierre, Pradeep K. Chintagunta, Amil Petrin, Bart Bronnenberg, Ron Goettler, P. B. (Seethu) Seetharaman, K. Sudhir, Raphael Thomadsen, and Ying Zhao, (2002). "Structural Applications of the Discrete Choice Model," *Marketing Letters*, 13 (3), 207-220.

*The Economist* (1992), "Mobile Telephones: A Way of Life", May 30, 19-25.

Jain, C. Dipak, Eitan Muller and Naufel J. Vilcassim, (1999), "Pricing Patterns of Cellular Phones and Phonecalls: A Segment-Level Analysis", *Management Science*, 45, 2, (February), 131-141.

Kadiyali, Vrinda, K. Sudhir, and Vithala R. Rao (2001). "Structural Analysis of Competitive Behavior: New Empirical Industrial Organization Methods in Marketing," *International Journal of Research in Marketing*, 18, 161-186.

Kadiyali, Vrinda, Pradeep K. Chintagunta, and Naufel Vilcassim (2000). "Manufacturer-Retailer Channel Interactions and Implications for Channel Power: An Empirical Investigation of Pricing in a Local Market," *Marketing Science*, 19 (2), 127-148.

Kadiyali, Vrinda, Naufel Vilcassim and Pradeep K. Chintagunta (1999). "Product Line Extensions and Competitive Market Interactions: An Empirical Analysis," *Journal of Econometrics*, 89, 339-363.

Kadiyali, Vrinda, Naufel J. Vilcassim and Pradeep K. Chintagunta (1996). "Empirical Analysis of Competitive Product Line Pricing Decisions: Lead, Follow, or Move Together?," *Journal of Business*, 69 (4), 459-487.

Kim, N. and P. M. Parker (1999), "Collusive Conduct in Private Label Markets," *International Journal of Research in Marketing,* 16, 143-155.

Mesher, Gene M. and Edward E. Zajac (1997), “The Political Economy of Telecommunications in Malaysia and Singapore: A Structure-Conduct-Performance Comparative Analysis”, *Information Economics and Policy*, 9, 183-202.

Parker, P. and L. Roller (1997), “Collusive Conduct in Duopolies: Multi-market Contact and Cross-Ownership in the Mobile Telephone Industry”, *RAND Journal of Economics*, 28(2), 304-322.

Sudhir, K, Pradeep K. Chintagunta and Vrinda Kadiyali (October 2003). “Time Varying Competition,” Working Paper, Yale School of Management.

Tirole, Jean (1988), *The Theory of Industrial Organization*, Cambridge, MA: The MIT Press.

Vilcassim, Naufel J. and Vrinda Kadiyali (1999). "Investigating Dynamic Multifirm Market Interactions in Price and Advertising," *Management Science*, 45 (4), 499-518.

Villas-Boas, Miguel J. and Russel S. Winer, (1999), “Endogeneity in Brand Choice Models”, *Management Science*, 45 (10), 1324-38.

## TABLE 1: KEY MARKET CHARACTERISTICS ACROSS COUNTRIES

| Country | Total # of Observations | Antitrust Policy Score | Maximum # of Competitors | Lead-time of Monopolist | Average Growth Rate % |
|---|---|---|---|---|---|
| Bahrain | 6 | n/a | 1 | n/a | 44 |
| Belgium | 7 | 6 | 1 | n/a | 44 |
| Cyprus | 5 | 4 | 1 | n/a | 99 |
| Denmark | 11 | 2 | 2 | 10 | 70 |
| Ecuador | 2 | 1 | 2 | 0 | 89 |
| El Salvador | 2 | 3 | 1 | n/a | 54 |
| Finland | 6 | 5 | 2 | 10 | 42 |
| Iceland | 6 | 4 | 1 | n/a | 25 |
| Malaysia | 7 | 1 | 6 | 4 | 120 |
| Malta | 6 | n/a | 1 | n/a | 63 |
| Oman | 4 | 2 | 1 | n/a | 21 |
| Poland | 5 | 4 | 2 | 4 | 1000 |
| Portugal | 6 | 4 | 2 | 3 | 443 |
| Singapore | 6 | 1 | 1 | n/a | 54 |
| Sri Lanka | 5 | 2 | 4 | 4 | 274 |
| Switzerland | 6 | 2 | 1 | n/a | 29 |
| Thailand | 6 | 3 | 3 | 4 | 93 |
| Turkey | 5 | 4 | 3 | 8 | 127 |
| Uruguay | 3 | 2 | 2 | 3 | 171 |

Countries where the maximum number of competitors is 1 had monopolies during the whole observation window. Lead-time of monopolist is n/a for these countries.

## TABLE 2a: KEY VARIABLES (MEANS) BY COUNTRY

| COUNTRY | *P* | *Q* | *PENET* | *AGE* | *TIME* | *ENERGY* | *POP* | *URBAN* | *PHONES* | *GNP* | *WAGES* | *LEND* | *OPCOST* | *LPOP* | *LPHONES* | *LGNP* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Belgium** | 365.84 | 87 954.57 | 0.009 | 5 | 14 | 0.20 | 10 026 010.14 | 95 | 5 223 551.28 | 16790 | 121.01 | 11.37 | 59 769.32 | 16.12 | 15.47 | 9.73 |
| **Bahrain** | 146.45 | 18 948.83 | 0.033 | 7.5 | 15.5 | 106.00 | 550 229.15 | 81 | 152 963.70 | 5592 | 118.71 | 10.80 | 27.69 | 13.22 | 11.94 | 8.63 |
| **Switzerland** | 230.99 | 348 227.67 | 0.049 | 6.5 | 15.5 | 0.15 | 7 004 750.00 | 60 | 6 297 270.25 | 30304 | 35.58 | 6.60 | 4 993.36 | 15.76 | 15.66 | 10.32 |
| **Cyprus** | 116.45 | 19 509.80 | 0.029 | 5 | 15 | 83.88 | 644 680.00 | 62 | 282 369.84 | 7724 | 80.60 | 8.86 | 35.62 | 13.37 | 12.55 | 8.95 |
| **Denmark** | 315.15 | 354 134.36 | 0.068 | 9 | 13 | 0.21 | 5 175 818.18 | 85 | 4 741 049.45 | 21461 | 101.35 | 11.73 | 9 368.83 | 15.46 | 15.37 | 9.97 |
| **Ecuador** | 284.37 | 33 817.00 | 0.003 | 0.5 | 16.5 | 79.25 | 11 348 500.00 | 55 | 397 197.50 | 1036 | 8.04 | 49.85 | 271 441.05 | 16.24 | 12.89 | 6.94 |
| **Finland** | 193.42 | 715 562.50 | 0.140 | 11.5 | 15.5 | 0.11 | 5 077 252.00 | 62 | 3 092 046.47 | 23410 | 58.18 | 9.88 | 3 798.00 | 15.44 | 14.94 | 10.06 |
| **Iceland** | 273.87 | 24 543.00 | 0.092 | 7.5 | 15.5 | 131.55 | 265 167.50 | 90 | 131 523.08 | 21835 | 183.84 | 13.38 | 5 843.83 | 12.49 | 11.79 | 9.99 |
| **Sri Lanka** | 325.81 | 34 067.00 | 0.002 | 5 | 16 | 88.88 | 18 068 808.00 | 22 | 198 756.89 | 454 | 2.95 | 14.28 | 3 047.33 | 16.71 | 12.20 | 6.12 |
| **Malta** | 301.88 | 6 978.50 | 0.019 | 3.5 | 15.5 | 106.88 | 367 415.00 | 85 | 172 159.94 | 5952 | 70.04 | 8.74 | 10.73 | 12.81 | 12.06 | 8.69 |
| **Malaysia** | 38.47 | 550 617.29 | 0.028 | 8 | 15 | 72.84 | 19 088 304.29 | 35 | 1 813 388.91 | 2226 | 21.75 | 8.15 | 1 352.07 | 16.76 | 14.41 | 7.71 |
| **Oman** | 192.5 | 8 338.25 | 0.004 | 9.50 | 16.5 | 97.75 | 2 142 030.00 | 9 | 124 237.74 | 6308 | 45.68 | 8.83 | 2 634.67 | 14.58 | 11.73 | 8.75 |
| **Poland** | 762.21 | 69 747.20 | 0.002 | 2 | 16 | 0.63 | 38 471 744 | 62 | 4 616 609.28 | 1862 | 12.32 | 35.15 | 1 679.15 | 17.47 | 15.35 | 7.53 |
| **Portugal** | 148.34 | 221 516.17 | 0.022 | 4.50 | 15.50 | 018 | 9 886 695 | 30 | 2 442 013.67 | 4439 | 88.95 | 18.14 | 333 696.82 | 16.11 | 14.71 | 8.40 |
| **Singapore** | 71.06 | 225 422.67 | 0.077 | 6 | 15.50 | 128.88 | 2 874 207.50 | 100 | 1 307 764.41 | 11 656 | 76.44 | 6.26 | 745.29 | 14.87 | 14.08 | 9.36 |
| **El Salvador** | 558.71 | 9 977.50 | 0.002 | 1.5 | 16.5 | 75.75 | 5 341 400 | 43 | 144 217.80 | 980 | 6.33 | 19.05 | 786.52 | 15.49 | 11.88 | 6.89 |
| **Thailand** | 98.92 | 476 975.83 | 0.008 | 7.50 | 15.50 | 62.75 | 58 240 156.67 | 18 | 1 048 322.82 | 1270 | 7.66 | 16.63 | 9 526.28 | 17.88 | 13.86 | 7.15 |
| **Turkey** | 437.30 | 312 766 | 0.005 | 8 | 16 | 0.09 | 61 212 000 | 60 | 7 121 464.57 | 1417 | 17.40 | 74.31 | 9 488 079.00 | 17.93 | 15.78 | 7.26 |
| **Uruguay** | 488.35 | 17 023 | 0.005 | 3 | 16 | 157 | 3 165 333.33 | 89 | 496 957.33 | 2539 | 19.87 | 97.17 | 1 333.04 | 14.97 | 13.12 | 7.84 |

The variables are defined as follows: *P*=monthly bill in US dollars, *Q*=number of cellular subscribers, POP=country population, TIME=trend in years, URBAN=percent of country's population residing in urban centers, GNP=GNP per capita in constant US dollars, PHONES=number of landline telephones installed in the country, ENERGY=retail prices of electricity in US dollars per unit, LEND=market lending rates in the country, WAGES=monthly wages of hourly workers in US dollars, OPCOST=operating costs of telecommunications network in millions of US dollars, AGE=age of cellular market in years.

## TABLE 2b: INTERNATIONAL CELLULAR TELEPHONE INDUSTRY DATA

### Summary Statistics on Full Data Set (104 observations)

| Variable | Mean | Standard Error | Minimum | Maximum |
|---|---|---|---|---|
| *P* | 261.69 | 175.28 | 36.36 | 878.21 |
| *Q* | 220,644.16 | 320,515 | 2,195 | 1,520,320 |
| POP | 13,555,379.98 | 18,181,028 | 259,577 | 63,898,000 |
| TIME | 15.24 | 2.08 | 8 | 18 |
| URBAN (%) | 62.78 | 27.38 | 9 | 100 |
| GNP (per capita) | 10,481.70 | 9,430 | 454 | 30,304 |
| PHONES | 2,436,934.31 | 2,319,796 | 117,048.29 | 7,433,956.46 |
| ENERGY | 55.50 | 53.13 | 0.09 | 157.00 |
| LEND | 18.61 | 20.51 | 6.26 | 97.17 |
| WAGES | 65.26 | 49.06 | 2.95 | 183.84 |
| OPCOST (million) | 487,456.96 | 2.03E+12 | 10.73 | 9,488,079.00 |
| COMP | 1.16 | 0.99 | 1 | 6 |
| POLICY | n/a | n/a | n/a | n/a |
| GROWTH | 1.44 | 3.08 | 0 | 24.45 |
| LEAD | 4.34 | 3.91 | 0 | 10 |
| AGE | 6.39 | 3.17 | 0 | 14 |

The variables are defined as follows: *P*=monthly bill in US dollars, *Q*=number of cellular subscribers, POP=country population, TIME=trend in years, URBAN=percent of country's population residing in urban centers, GNP=GNP per capita in constant US dollars, PHONES=number of landline telephones installed in the country, ENERGY=retail prices of electricity in US dollars per unit, LEND=market lending rates in the country, WAGES=monthly wages of hourly workers in US dollars, OPCOST=operating costs of telecommunications network in millions of US dollars, COMP=number of cellular companies operating in the country, POLICY=measure of severity of anti-trust policy (not available for all observations in this data set), GROWTH=average growth rate in cellular subscriber base, LEAD=monopolist's lead-time before competition is allowed, AGE=age of cellular market in years.

## TABLE 2c: INTERNATIONAL CELLULAR TELEPHONE INDUSTRY DATA

### Summary Statistics on Competitive Data Set (56 observations)*

| Variable | Mean | Standard Error | Minimum | Maximum |
|---|---|---|---|---|
| *P* | 286.43 | 208.77 | 36.36 | 878.20 |
| *Q* | 329,209.46 | 386,096.56 | 2,195.00 | 1,520,320.00 |
| POP | 22,334,509.14 | 20,930,009.49 | 3,149,000.00 | 63,898,000.00 |
| TIME | 15.14 | 2.31 | 8 | 18 |
| URBAN (%) | 52.44 | 24.82 | 18 | 89 |
| GNP (per capita) | 8,120.02 | 9,414.33 | 454.00 | 23,410.00 |
| PHONES | 2,969,803.30 | 2,079,467.40 | 194,348.22 | 7,433,956.46 |
| ENERGY | 35.14 | 46.24 | 0.09 | 157.00 |
| LEND | 26.13 | 25.60 | 8.15 | 97.17 |
| WAGES | 43.47 | 38.66 | 2.95 | 101.35 |
| OPCOST (million) | 896,527.80 | 2.72 | 1,333.04 | 9,488,079.00 |
| COMP | 2.14 | 1.10 | 1 | 6 |
| POLICY | 2.83 | 1.30 | 1 | 5 |
| GROWTH | 2.28 | 3.91 | 1 | 24.45 |
| LEAD | 5.87 | 3.61 | 0 | 10 |
| AGE | 6.80 | 3.12 | 0 | 14 |

The variables are defined as follows: *P*=monthly bill in US dollars, *Q*=number of cellular subscribers, POP=country population, TIME=trend in years, URBAN=percent of country's population residing in urban centers, GNP=GNP per capita in constant US dollars, PHONES=number of landline telephones installed in the country, ENERGY=retail prices of electricity in US dollars per unit, LEND=market lending rates in the country, WAGES=monthly wages of hourly workers in US dollars, OPCOST=operating costs of telecommunications network in millions of US dollars, COMP=number of cellular companies operating in the country, POLICY=measure of severity of anti-trust policy, GROWTH=average growth rate in cellular subscriber base, LEAD=monopolist's lead-time before competition is allowed, AGE=age of cellular market in years.

* The competitive dataset includes only those countries in which more than one firm participated in the cellular telephone market. For these countries however, there are some observations for which the market was a monopoly before competitive entry. Specifically, there are 16 monopoly observations and 40 non-monopoly observations.

**TABLE 3: PEARSON CORRELATION COEFFCIENTS, N=104 - Prob > |r| under H0: Rho=0**

| | POLICY | ENERGY | COMP | LEAD | TIME | PRICE | QTY | AGE | POP | PENET | URBAN | PHONES | GNP | WAGES | LEND | OPCOST | log(POP) | log(PHONES) | log(GNP) | GROWTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **POLICY** | 1.00 | | | | | | | | | | | | | | | | | | | |
| **ENERGY** | **-0.42** | 1.00 | | | | | | | | | | | | | | | | | | |
| | **<.0001** | | | | | | | | | | | | | | | | | | | |
| **COMP** | -0.23 | -0.05 | 1.00 | | | | | | | | | | | | | | | | | |
| | 0.03 | 0.62 | | | | | | | | | | | | | | | | | | |
| **LEAD** | 0.15 | **-0.51** | 0.12 | 1.00 | | | | | | | | | | | | | | | | |
| | 0.15 | **<.0001** | 0.23 | | | | | | | | | | | | | | | | | |
| **TIME** | -0.02 | 0.19 | 0.30 | -0.26 | 1.00 | | | | | | | | | | | | | | | |
| | 0.84 | 0.05 | 0.00 | 0.01 | | | | | | | | | | | | | | | | |
| **PRICE** | 0.30 | -0.27 | -0.22 | 0.11 | 0.03 | 1.00 | | | | | | | | | | | | | | |
| | 0.00 | 0.00 | 0.02 | 0.25 | 0.78 | | | | | | | | | | | | | | | |
| **QTY** | -0.07 | -0.32 | **0.56** | 0.35 | **0.40** | -0.23 | 1.00 | | | | | | | | | | | | | |
| | 0.51 | 0.00 | **<.0001** | 0.00 | **<.0001** | 0.02 | | | | | | | | | | | | | | |
| **AGE** | -0.01 | -0.17 | 0.30 | 0.30 | **0.40** | -0.34 | 0.67 | 1.00 | | | | | | | | | | | | |
| | 0.89 | 0.08 | 0.00 | 0.00 | **<.0001** | 0.00 | <.0001 | | | | | | | | | | | | | |
| **POP** | 0.10 | -0.30 | **0.47** | 0.18 | 0.11 | 0.21 | 0.22 | 0.01 | 1.00 | | | | | | | | | | | |
| | 0.32 | 0.00 | **<.0001** | 0.08 | 0.25 | 0.03 | 0.03 | 0.92 | | | | | | | | | | | | |
| **PENET** | 0.04 | -0.05 | 0.01 | 0.26 | 0.36 | -0.19 | **0.64** | **0.66** | -0.30 | 1.00 | | | | | | | | | | |
| | 0.72 | 0.61 | 0.92 | 0.01 | 0.00 | 0.06 | **<.0001** | **<.0001** | 0.00 | | | | | | | | | | | |
| **URBAN** | 0.18 | 0.09 | **-0.51** | 0.29 | -0.20 | 0.21 | -0.15 | -0.07 | **-0.44** | 0.29 | 1.00 | | | | | | | | | |
| | 0.08 | 0.36 | **<.0001** | 0.00 | 0.04 | 0.03 | 0.12 | 0.51 | **<.0001** | 0.00 | | | | | | | | | | |
| **PHONES** | 0.27 | **-0.85** | -0.04 | **0.55** | -0.18 | 0.36 | 0.28 | 0.16 | 0.33 | 0.06 | 0.20 | 1.00 | | | | | | | | |
| | 0.01 | **<.0001** | 0.68 | **<.0001** | 0.07 | 0.00 | 0.00 | 0.09 | 0.00 | 0.58 | 0.04 | | | | | | | | | |
| **GNP** | 0.15 | -0.34 | -0.37 | 0.27 | -0.23 | -0.07 | 0.19 | 0.37 | **-0.46** | **0.53** | **0.49** | **0.44** | 1.00 | | | | | | | |
| | 0.14 | 0.00 | 0.00 | 0.01 | 0.02 | 0.51 | 0.05 | 0.00 | **<.0001** | **<.0001** | **<.0001** | **<.0001** | | | | | | | | |
| **WAGES** | 0.37 | 0.10 | **-0.46** | 0.03 | -0.21 | -0.15 | -0.18 | 0.17 | **-0.57** | 0.33 | **0.63** | -0.07 | **0.52** | 1.00 | | | | | | |
| | 0.00 | 0.31 | **<.0001** | 0.80 | 0.03 | 0.14 | 0.07 | 0.09 | **<.0001** | 0.00 | **<.0001** | 0.51 | **<.0001** | | | | | | | |
| **LEND** | 0.06 | 0.01 | 0.12 | 0.05 | 0.15 | **0.50** | -0.09 | -0.22 | **0.45** | -0.26 | 0.03 | 0.20 | **-0.38** | -0.36 | 1.00 | | | | | |
| | 0.60 | 0.92 | 0.22 | 0.60 | 0.14 | **<.0001** | 0.35 | 0.02 | **<.0001** | 0.01 | 0.77 | 0.04 | **<.0001** | 0.00 | | | | | | |
| **OPCOST** | 0.17 | -0.25 | 0.14 | 0.21 | 0.08 | 0.22 | 0.06 | 0.10 | **0.59** | -0.15 | -0.03 | 0.46 | -0.22 | -0.22 | **0.62** | 1.00 | | | | |
| | 0.11 | 0.01 | 0.17 | 0.03 | 0.40 | 0.02 | 0.52 | 0.29 | **<.0001** | 0.14 | 0.74 | <.0001 | 0.02 | 0.03 | **<.0001** | | | | | |
| **log(POP)** | -0.03 | **-0.57** | **0.52** | **0.44** | 0.03 | 0.21 | 0.33 | 0.00 | **0.79** | -0.25 | **-0.50** | **0.53** | -0.29 | **-0.68** | 0.33 | 0.37 | 1.00 | | | |
| | 0.77 | **<.0001** | **<.0001** | **<.0001** | 0.80 | 0.03 | 0.00 | 0.99 | **<.0001** | 0.01 | **<.0001** | **<.0001** | 0.00 | **<.0001** | 0.00 | 0.00 | | | | |
| **log(PHONES)** | 0.18 | **-0.84** | 0.11 | **0.68** | -0.20 | 0.19 | **0.41** | 0.17 | 0.36 | 0.11 | 0.12 | **0.91** | 0.36 | -0.15 | 0.14 | 0.29 | **0.65** | 1.00 | | |
| | 0.08 | **<.0001** | 0.28 | **<.0001** | 0.04 | 0.06 | **<.0001** | 0.09 | 0.00 | 0.27 | 0.24 | **<.0001** | 0.00 | 0.12 | 0.17 | 0.00 | **<.0001** | | | |
| **log(GNP)** | 0.21 | -0.22 | **-0.50** | 0.22 | -0.25 | -0.17 | 0.11 | 0.34 | **-0.60** | **0.51** | **0.61** | 0.31 | **0.91** | **0.70** | **-0.43** | -0.27 | **-0.50** | 0.26 | 1.00 | |
| | 0.05 | 0.02 | **<.0001** | 0.02 | 0.01 | 0.09 | 0.27 | 0.00 | **<.0001** | **<.0001** | **<.0001** | 0.00 | **<.0001** | **<.0001** | **<.0001** | 0.01 | **<.0001** | 0.01 | | |
| **GROWTH** | 0.11 | -0.20 | 0.20 | -0.03 | 0.34 | 0.33 | 0.09 | -0.11 | 0.26 | -0.08 | -0.16 | 0.12 | -0.28 | -0.23 | 0.19 | -0.01 | 0.30 | 0.17 | -0.29 | 1.00 |
| | 0.31 | 0.04 | 0.04 | 0.77 | 0.00 | 0.00 | 0.37 | 0.26 | 0.01 | 0.41 | 0.10 | 0.24 | 0.00 | 0.02 | 0.06 | 0.96 | 0.00 | 0.09 | 0.00 | |

**TABLE 4: CALIBRATION WITH MONOPOLY OBSERVATIONS ONLY**

**(Nonlinear 3SLS)**

| Variable | Parameter Estimate | Standard Error | T-statistic |
|---|---|---|---|
| **SUPPLY** | | | |
| $Q$ ($\gamma_1$) | 0.000041 | 0.000045940 | 0.89 |
| ENERGY ($\gamma_2$) | -1.2609 | 0.2977 | -4.24 |
| LEND ($\gamma_3$) | 8.6641 | 1.2993 | 6.67 |
| WAGES ($\gamma_4$) | -0.3849 | 0.3597 | -1.07 |
| OPCOST ($\gamma_5$) | -4.51 E-11 | 1.2561E-11 | -3.59 |
| **DEMAND** | | | |
| Log ($Q$) ($\eta_1$) | -219.5654 | 2.7911 | -78.67 |
| Log(POP) ($\eta_2$) | 107.9315 | 56.4653 | 1.91 |
| TIME ($\eta_3$) | 41.2934 | 14.0702 | 2.93 |
| Log(GNP) ($\eta_4$) | 78.9030 | 54.2056 | 1.46 |
| Log(PHONES) ($\eta_5$) | 70.8600 | 52.6535 | 1.35 |
| URBAN ($\eta_6$) | 3.1074 | 1.4510 | 2.14 |
| **CONDUCT** | | | |
| $\theta$ | **1.2727** | **0.4337** | **2.93 ($\theta \neq 0$); 0.63 ($\theta \neq 1$)** |

Number of observations used: 64

Objective value at parameter estimates: 0.5662

**TABLE 5: EMPIRICAL RESULTS, "AVERAGE" $\theta$ MODEL**

**(Nonlinear 3SLS)**

| Variable | Parameter Estimate | Standard Error | T-statistic |
|---|---|---|---|
| **SUPPLY** | | | |
| $Q$ ($\gamma_1$) | 0.0000979020 | 0.000170700 | 0.57 |
| ENERGY ($\gamma_2$) | -2.4302 | 0.7309 | -3.32 |
| LEND ($\gamma_3$) | 9.4111 | 1.1903 | 7.91 |
| WAGES ($\gamma_4$) | -0.3528 | 0.5867 | -0.60 |
| OPCOST ($\gamma_5$) | -4.5069E-11 | 1.2147E-11 | -3.71 |
| **DEMAND** | | | |
| Log ($Q$) ($\eta_1$) | -175.8713 | 22.8760 | -7.69 |
| Log(POP) ($\eta_2$) | 240.3629 | 57.1719 | 4.20 |
| TIME ($\eta_3$) | 72.8302 | 11.0519 | 6.59 |
| Log(GNP) ($\eta_4$) | 214.4263 | 59.0730 | 3.63 |
| Log(PHONES) ($\eta_5$) | -30.1493 | 39.1192 | -0.77 |
| URBAN ($\eta_6$) | 3.9106 | 1.1213 | 3.49 |
| **CONDUCT** | | | |
| $\theta$ | **0.7187** | **0.2726** | **2.64** |

Number of observations used: 56

Objective value at parameter estimates: 0.9044

**TABLE 6: EMPIRICAL RESULTS, FULL MODEL WITH $\theta$=$\theta$($\mu$)**

**(Nonlinear 3SLS)**

| Variable | Parameter Estimate | Standard Error | T-statistic |
|---|---|---|---|
| **SUPPLY** | | | |
| $Q$ ($\gamma_1$) | -0.0001126300 | 0.000204400 | -0.55 |
| ENERGY ($\gamma_2$) | -2.8630 | 0.9810 | -2.92 |
| LEND ($\gamma_3$) | 10.7669 | 1.4396 | 7.48 |
| WAGES ($\gamma_4$) | -0.1743 | 0.58269 | -0.30 |
| OPCOST ($\gamma_5$) | -5.2595E-11 | 1.3764E-11 | -3.82 |
| **DEMAND** | | | |
| Log ($Q$) ($\eta_1$) | -140.2458 | 17.9675 | -7.81 |
| Log(POP) ($\eta_2$) | 192.5262 | 49.8733 | 3.86 |
| TIME ($\eta_3$) | 60.8190 | 9.2508 | 6.57 |
| Log(GNP) ($\eta_4$) | 141.4660 | 50.1920 | 2.82 |
| Log(PHONES) ($\eta_5$) | -13.9249 | 35.4723 | -0.39 |
| URBAN ($\eta_6$) | 5.1723 | 1.0128 | 5.11 |
| **CONDUCT** | | | |
| COMP ($\beta_1$) | 0.2193 | 0.1963 | 1.12 |
| **POLICY ($\beta_2$)** | **-0.4067** | **0.1871** | **-2.17** |
| GROWTH ($\beta_3$) | 0.0493 | 0.0518 | 0.95 |
| **LEAD ($\beta_4$)** | **0.2317** | **0.0980** | **2.36** |

Number of observations used: 56

Objective value at parameter estimates: 0.9215