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An Empirical Analysis of the State of Competition in OECD Mobile Wireless Markets

ABSTRACT

Contra the current trend of deregulation, mobile wireless markets in the OECD member states appear, until recently, to have been more or less concentrated. The study estimates the equations for market concentration, mobile prices, and profits using annual panel data from 24 OECD member states for the 1998-2009 period, in order to assess their interaction. Mobile prices, measured by revenue per minute in constant USD PPP, are regarded as a direct measure of consumer welfare. Estimation results indicate that in the second half of the 2000s, market concentration had no effect on mobile prices, whereas the positive relationship between market concentration and profits persisted. In other words, the market-power hypothesis is rejected in the second half of the 2000s. This empirical result provides a strong case for a recent lenient approach towards regulation and merger attempts in OECD mobile wireless markets. Additionally, the study provides evidence that regulatory policies have affected mobile market structure and performance.

JEL Codes: L11, L96

Keywords: Mobile wireless markets, market structure, market performance, regulatory policy, competition

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I. Introduction

Many national regulatory authorities for telecommunications services regard their mobile wireless markets (hereafter referred simply as mobile markets) as effectively competitive. For example, the FCC has continued to find effective competition in its analyses of competition with regard to US mobile markets.¹ Ofcom (2003) concluded that no mobile network operators (MNOs), either by themselves or jointly, had significant market power in the wholesale mobile access and call origination market in the UK. Considering that mobile markets are effectively competitive, telecommunications-specific regulators often allowed mergers between two competing MNOs. The FCC has approved two gigantic merger attempts in the US mobile markets; a merger between Cingular and AT&T Wireless in 2004, and a merger between Sprint and Nextel in 2005. Recently, the merger attempt between T-Mobile and Orange in the UK mobile markets has won conditional EU approval. Additionally, the EU's new regulatory regime, which went into effect in 2008, recommended the abolition of all regulation in mobile markets, with the exception of mobile voice call termination. This policy change may be regarded as a natural move, as no government interventions should be required in effectively competitive markets.

Contrary to this laissez-faire approach, mobile markets in many developed countries, especially in the OECD member states, appear to continue to be more or less concentrated. The Herfindahl-Hirschman index (HHI) in a majority of OECD member states' mobile markets ranges between 2,000 and 5,000. These HHI values do not indicate the presence of effective competition by the standards laid out in the US Department of Justice's merger guidelines, which view a market as highly concentrated if its post-merger HHI exceeds 1,800. Moreover, the available spectrum and technology restricts further facility-based entry into national mobile markets. In fact, substantial changes in market share rankings were frequently uncommon in mobile markets. Many MNOs enjoy high and stable profits which may be attributable to concentrated mobile markets. All of these observations suggest that mobile markets are

¹ The US Congress required the FCC to submit annual reports that analyze competitive conditions in the commercial mobile radio services (CMRS) markets. The CMRS competition reports, which began to be released after 1996, have consistently indicated that the US mobile market is effectively competitive. The FCC(2010), which is the 14th competition report, integrates an analysis of CMRS into an analysis of all mobile wireless services.

inherently oligopolistic; this view may not be compatible with the present state of regulatory policies in OECD mobile markets.

To resolve this seeming contradiction, this study analyzes the relationship between market structure and performance in OECD member states' mobile markets; specifically, it assesses whether or not concentrated markets led to high mobile prices. In the literature concerning industrial organization, two alternative theories suggest different predictions of the results of concentrated market structure. The traditional market-power hypothesis (structure-conduct-performance hypothesis) argues that more concentrated market structure results in worse market performance. On the other hand, the efficiency (efficient-structure) hypothesis believes that seemingly concentrated markets do not always harm consumer welfare. This argument holds that differences in firm-specific efficiency may create unequal market shares and hence, high concentration levels. In OECD mobile markets, if the market-power hypothesis is not applicable and/or if the efficiency hypothesis is accepted, then seemingly concentrated mobile market structure does not pose any serious threat to consumer welfare, and also does not require government intervention. In other words, recent lenient regulatory policies in OECD mobile markets have gained empirical ground.

To empirically assess the two alternative hypotheses, the study estimates the equation for market concentration/HHI, mobile prices, and profits by relying on annual panel data of 24 OECD member states for the 1998-2009 period.² Mobile prices are regarded as a direct measure of consumer welfare. In empirical analysis, mobile prices are measured in terms of revenue per minute (RPM) in constant USD PPP; this is calculated by dividing the monthly voice-only average revenue per user (ARPU) by minutes of use (MOU). The study proxies profits by earnings before interest, tax, depreciation, and amortization (EBITDA) service margin, which is equal to the ratio of EBITDA to total revenues.³ The EBITDA (service) margin is widely employed as one of the applicable measures for the international comparison of profitability.

² Iceland, Luxembourg, and the Slovak Republic are excluded, as these countries are not covered by Merrill Lynch's Global Wireless Matrix. Additionally, Canada, Mexico, and USA are not included as well, partly because a majority of MNOs in these countries started from regional carriers so that it is difficult to calculate HHI at the national level, and partly because RPM in these countries tends to be underestimated.

³ An advantage of EBITDA is that it is widely employed by industry observers as an indicator of profitability in the telecommunications sector (FCC, 2010). To the extent that capital expenditures are proportionately similar across firms and over time, EBITDA can be a useful

The literature on mobile markets focuses principally on global and national mobile telephone diffusion.⁴ Another type of empirical studies assesses the market structure-performance relationship for mobile markets. In particular, Grzybowski (2005) and Koski and Kretschmer (2005) analyze the impact of regulatory and competition variables on the demand and price for mobile telephone services across the EU and 25 industrialized countries, respectively. Until recently, however, few studies have attempted to directly tackle the state of competition in mobile markets.

The paper is organized as follows. Section 2 discusses the evolution of competition in OECD member state mobile markets. Section 3 presents an empirical model with a brief explanation for two opposing views on market structure and performance; the market-power hypothesis and the efficiency hypothesis. Section 4 reports the estimation results. Finally, our conclusions are presented, with a brief discussion on the relevant policy implications.

II. Competition and Deregulation in OECD Mobile Markets

Market Structure and Performance in OECD Mobile Markets

With the rapid diffusion of mobile services, mobile markets have been transformed into one of the most competitive parts of the telecommunications sector. Table 1 provides sample means for several indicators of competition in OECD member state mobile markets. First of all, the average value for subscriber-based HHI dropped from 4,436 in 1999 to 3,589 in 2009, and incumbent MNOs, on the average, lost a market share of 10.3% to new entrants for the same period. The slowdown in the biennial decrease of the two indices, however, is observed as well. The average number of MNOs increased in the early 2000s, achieved a peak value around 2005, and began to drop due to mergers between MNOs. Thus, it appears that competition in OECD mobile markets is progressing, but at a slower than expected rate.

[Table 1 here]

measure of relative performance. Herein, the calculation of the EBITDA service margin is based on data for EBITDA and revenues obtained solely from mobile services, excluding income and revenues from the non-mobile services sector (e.g., mobile handset sales). For the period 1998-2001 when the relevant data for EBITDA service margin is unavailable, it is extrapolated using the EBITDA margin data.

⁴ For a brief survey on these empirical studies, refer to the study of Gans *et al.* (2005).

Competition has also led to lower mobile prices, which in turn generated further diffusion of mobile telephones and also, to greater variety and higher quality of mobile services. The average mobile prices, measured by RPM in constant USD PPP, experienced a substantial drop from 0.382 constant USD PPP in 1999 to 0.121 constant USD PPP in 2009. Concurrently, the average mobile subscriptions per 100 persons increased three-fold over the sample period, with the average MOU evidencing a steady increase in the 2000s. Contrary to this increase in both mobile subscriptions and mobile services usage, the number of fixed telephone lines per 100 persons was reduced by approximately 30% over the same period.

The average ratio of prepaid to total subscriptions dropped steadily in the 2000s, which may have induced increased customer loyalty and hence, reduced competition. It is commonly accepted that prepaid subscribers tend to switch mobile operators more frequently than postpaid subscribers. On the other hand, some statistics suggest increased competition over time. The average monthly churn rate increased in the second half of the 2000s, from 1.68% in 2005 to 2.16% in 2009, thus indicating more frequent switching between mobile operators. The average level of profits, whether it is measured by the EBITDA margin or by the EBITDA service margin, clearly decreased after 2003. These mixed observations of the state of competition in OECD mobile markets necessitate a formal econometric analysis.

The extent of competition is uneven across OECD member states. Table 2 groups OECD member states by their 2009 national HHI value, and Table 3 presents some market and regulatory characteristics for each group. Detailed explanations of some variables in Table 3 are provided in Table 4. While all member state mobile markets are concentrated in accordance with the standards of the US Department of Justice's merger guidelines, casual observations suggest the presence of tiers of market concentration. For example, the UK, Germany, Poland, and Italy record HHIs of less than 3,000, and are regarded as the most competitive among OECD member states. The majority of European member states, including Spain and France, are placed in the second and third groups (with $3,000 \leq \text{HHI} < 3,500$ and with $3,500 \leq \text{HHI} < 4,000$, respectively). The fourth group (with $\text{HHI} \geq 4,000$) has substantially more concentrated markets.

[Table 2 here]

Four countries classed in the first group, on the average, retain more than four MNOs, as well as the longest competition periods. In these countries, at least one of their MNOs is owned by global mobile operators. In this study, the global mobile operators include Vodafone, Deutsch Telecom T-Mobile, and France Telecom Orange. The tendency for more concentrated market structure to be associated with less operators and shorter competition periods can be readily observed. In particular, the number of MNOs in the fourth group of countries is typically no more than three. For example, New Zealand and Norway are served by duopoly operators. It appears that less concentrated mobile markets evidence better market performance. The first and second groups, on the average, experience lower RPM, lower EBITDA (service) margins, higher mobile subscriptions per 100 persons, and higher ratios of data revenues than the third and fourth groups. On the other hand, there exist no systematic variations across groups in other variables such as monthly churn rate and monthly MOU.

[Table 3 here]

Lenient Regulatory Policies and Deregulation in Mobile Markets

Mobile markets, in which more than two facility-based MNOs compete, are frequently regarded as competitive. This competitive mobile market structure is often compared with a near-monopolistic fixed telecommunications market structure, in which a former incumbent monopoly continues to hold a strong market dominant position. As a consequence, regulators in OECD member states focus on regulation in fixed telecommunications markets, particularly broadband markets, and do not evidence deep concern toward the status of competition in mobile markets. For example, as indicated in Table 4, a majority of merger attempts between two competing MNOs have been approved by regulators. Not only small latecomers, but also gigantic incumbents have been involved in these mergers. A merger between two latecomers, Orange UK and T-Mobile UK, formed the largest MNO in the UK. In the Netherlands, two merger attempts resulted in a sharp decline in the number of MNOs, from five to three. Although several new MNOs have entered into mobile markets through 3G licensing, mergers between

competing MNOs have led to reductions in the average number of MNOs as shown in Table 1 and also, to more concentrated market structures in some countries.⁵

[Table 4 here]

In many countries, service-based competition complements facility-based competition between MNOs. In fact, many MNOs resell their mobile services in wholesale markets to either mobile virtual network operators (MVNOs) or simple service providers. The presence of these resellers contributes to strengthening service-based competition in retail markets. When MNOs have little motivation to resell mobile services, mandatory resale contracts with regulation on resale prices may be an effective method to facilitate service-based competition in mobile markets.

These mandatory resale obligations, however, have been abolished in a majority of OECD member states. For example, after assessing the status of competition in mobile markets, the EC eliminated ‘wholesale access and call origination on public mobile networks’ from the relevant product and service markets susceptible to *ex ante* regulation. The EC believed that effective competition in retail markets would be maintained without any regulation in wholesale markets. As a consequence, mandatory resale obligations were withdrawn in all EU member states except for Spain (Dippon and Banerjee, 2006).

In summary, a lenient approach toward regulatory policies in mobile markets is commonly accepted in OECD member states, despite seemingly stagnant progress in competition and even increasing market concentration. As a matter of course, the question as to whether concentrated market structure will not harm consumer welfare is an imminent regulatory policy issue.

III. Empirical Models

Two Opposing Views on Concentration and Performance

The literature on industrial organization states that the relationship between market structure /concentration and performance is not simple or straightforward. For example, strategic

⁵ For example, the FCC(2010) indicates that concentration in the US mobile markets, measured by the HHI, has increased 32 percent since 2003. From 2003 to 2008, the average HHI has increased from 2,151 to 2,848, an increase of 697.

interaction between competing firms under oligopolistic market structure conditions may generate different market outcomes. The threat of potential competition may suppress an incumbent firm's monopolistic pricing behavior.

In particular, industrial organization theories suggest two competing hypotheses regarding the relationship between market structure/concentration and performance. A positive relationship between market concentration and profits is frequently observed in many industries, including mobile markets. With regard to the reasons for this positive concentration-profit relationship, the traditional market-power hypothesis argues that firms extract monopolistic profits in concentrated markets by exercising their ability to offer higher prices. In other words, it states that the positive concentration-profit relationship reflects the setting of prices less favorable to consumers in more concentrated markets, as a result of non-competitive behavior. On the other hand, the efficiency hypothesis states that efficient firms increase in size and market share due to their ability to generate higher profits, which generally leads to more concentrated market structure. The market-power hypothesis predicts that persistently or increasingly concentrated markets will harm consumer welfare, whereas the efficiency hypothesis predicts the opposite.

Moreover, in mobile markets, a measure of market concentration such as HHI may generate misleading consumer welfare information, as it does not take into consideration the presence of service-based competition in retail markets. MVNOs and service providers frequently perform a key role in searching for new consumers and niche markets, cutting mobile prices of MNOs, and hence, contributing to active price and/or non-price competition in retail markets. In this case, even persistently or increasingly concentrated markets on the basis of facility-based competition may not be indicative of poor market performance.

The study attempts to assess the market concentration-price relationship, as well as the market concentration-profit relationship. While the two hypotheses yield an equivalent prediction for the concentration-profit relationship, they imply opposite predictions for the concentration-price relationship. The efficiency hypothesis suggests that efficient firms are able to reduce costs (and hence price) concurrently with increases in their market share. Under the market-power hypothesis, more concentrated market structures imply individually or collectively stronger market power, which lead to higher prices. Therefore, a joint investigation into the concentration-price prediction and the concentration-profit prediction enables a researcher to

empirically distinguish the two competing hypotheses (Hannan, 1991).⁶ A positive (negative, respectively) concentration-price relationship, along with a positive concentration-profit relationship, supports the market-power (efficiency, respectively) hypothesis. The lack of a clear relationship does not confirm the relative merits of the two hypotheses, and also indicates that a market concentration measure does not provide sufficient information regarding consumer welfare. Ultimately, the level of prices, and not market concentration, constitutes a direct measure of consumer welfare. Thus, the research strategy of this study is focused on prices.

Specifications of the Econometric Model

To empirically evaluate the two alternative hypotheses, the study specifies the following three regression equations for market concentration (HHI), prices (RPM) and profits (PROF).

$$HHI_{it} = \alpha^1 + \sum_{j=1}^l \delta_j^1 x_{jit}^1 + u_i^1 + \varepsilon_{it}^1$$

$$RPM_{it} = \alpha^2 + \beta^2 HHI + \sum_{j=1}^m \delta_j^2 x_{jit}^2 + u_i^2 + \varepsilon_{it}^2$$

$$PROF_{it} = \alpha^3 + \beta^3 HHI + \sum_{j=1}^n \delta_j^3 x_{jit}^3 + u_i^3 + \varepsilon_{it}^3$$

where i is the country (or unit) index and t is the calendar year (or time) index. u_i measures unobservable unit-variant and time-invariant country effects, whereas $\varepsilon_{i,t}$ is an unobservable unit-variant and time-variant random disturbance. As the empirical analysis is based on panel data, unobservable country effects should be accounted for. The country-specific individual

⁶ Industry-specific studies of the structure-performance relationship, especially tests of the two competing hypotheses, have been frequently conducted in the banking industry. One of the methods employed in these studies incorporates measures of efficiency directly into the model. For example, Berger (1995) used a cost frontier model to derive measures of efficiency and then incorporated the efficiency measure into the structure-performance relationship. This method, however, cannot be used in this study, partly because input data are not publicly available in mobile markets and partly because the study does not use company data, but country data. Alternatively, Berger and Hannan (1989) used price data to test the structure-performance relationship, rejecting the usual form of the efficient-structure hypothesis. The study follows this research method. Refer to Goldberg and Rai (1996) for a brief survey of the banking literature regarding the structure-conduct-performance relations.

effects term accounts for any inherent differences in efficiency and cost structure.⁷ x_{jit} refers to the j -th control variable, which represents market conditions and regulatory setting.

In the above regression equations, it is assumed that mobile market concentration (HHI) affects mobile prices (RPM) and profits (PROF). Thus, the variable HHI is included as one of the explanatory variables in prices and profits equations. On the other hand, the mobile market concentration (HHI) is assumed to be determined principally by regulatory settings. The main concern of the empirical analysis is the regression coefficient of HHI in the prices equation (β^2). If the market-power (efficiency) hypothesis were true, its parameter estimate should be statistically significant and should have a positive (negative) sign.

Empirical analysis is conducted herein using data for three sample periods, respectively; the whole period (period 1998-2009), the first half of the 2000s (period 1998-2004), and the second half of the 2000s (period 2005-2009). The whole sample period is divided into the first and second period in order to evaluate changes in the effects of market concentration between the first and second half of the 2000s. A border year between the first and second period is selected because service-based competition in mobile markets began to be activated around 2005, particularly in European Union member states.

Explanatory Variables

Regulatory, institutional, and market environmental variables may influence market structure, prices, and profits. In the HHI equation, mobile market concentration (HHI) is assumed to be affected by the number of national mobile operators (NOOP), the competition period (COMP)--which is years elapsed since the introduction of competition,⁸ average lead-time (LEAD)--which

⁷ Whether a country adopts the receiving party pays (RPP) principle or the calling party pays (CPP) principle may affect the dependent variables. For example, Littlechild (2006) argues that with RPP, average revenue per call is significantly lower, and average MOU per subscriber is significantly higher, whereas the mobile penetration rate is not significantly different. The study does not consider this difference in the mobile payment system, as the two countries adopting the RPP system among OECD member states (Canada and USA) are excluded from the sample countries.

⁸ Whenever an operator is present at any point of time in a specific year, the operator is included in the calculation of the number of operators (NOOP) for the year. Only facility-based competitors are included among the NOOP due to a paucity of data for MVNO and simple service providers.

is the average of differences in entry year between an incumbent and new entrants, the introduction of mobile number portability (MNP), whether a former fixed telecommunications market monopoly is an incumbent operator in mobile markets or not (INCUM), and the presence of global mobile carriers operating in domestic markets (GLOB). In this study, MNP, INCUM, and GLOB are all dummy variables, detailed definitions of which are provided in Table 5.

The price (RPM) equation specification assumes that mobile price is affected by competitive environments and marginal cost.⁹ The competitive environments in mobile markets are expected to be measurable by mobile number portability (MNP) as well as market concentration (HHI). The availability of mobile number portability reduces the switching costs of customers who want to change operators and hence, is expected to intensify price competition. As publicly available information does not accommodate the calculation of marginal service provision cost, four proxy variables are used for estimation, which attempt to capture economies of scale and density. The proxy variables considered in the price equation are as follows: mobile service subscribers (SUBS), SUBS squared (viz., $SUBS^2 = SUBS2$), national population density (PDEN), and the rural to total population proportion (RPOPL).¹⁰

Finally, in the profit (PROF) equation, four explanatory variables are included to control for profitability across countries and years: mobile penetration ratio (CDEN), the presence of global mobile operators (GLOB), the digital subscriber ratio (DSR) which equals the ratio of digital to total mobile subscriptions, and the duration of 3G investments (INVEST). The variable INVEST is equal to unity for the period of 3G investments and otherwise, is equal to zero.¹¹

These variables are surmised to have mixed effects on the profitability of MNOs. For example, the mobile penetration ratio is closely associated with the stage of market development,

⁹ This assumption appears reasonable. For example, in the Cournot oligopolistic model, the weighted average of firms' price-cost margins (or Lerner index) is proven to equal the HHI divided by the absolute value of the market demand elasticity. Then, variations in prices are associated with differences in HHI and marginal cost.

¹⁰ Variables reflecting differences in marginal cost cannot be considered in the analysis because comparable industry-specific input prices are seldom available. When input price variables, such as real interest, marginal corporate tax rates, and unit labor costs, are included in price and profit equations, their coefficients are frequently insignificant. These results are consistent with the results reported by Grzybowski (2005), who unsuccessfully used crude measures of labor and capital costs.

¹¹ Due to a lack of appropriate data regarding 3G investments, the duration of 3G investments is proxied by the period extending from the year when any MNO launched 3G services the first time, to the year in which the last remaining MNO introduced 3G services.

which in turn affects profits. Firms tend to have normal profits in mature markets. On the other hand, high mobile penetration rate may contribute to increases in revenues and reductions in cost due to economies of density, thereby increasing operating incomes. Digital mobile services can facilitate wireless data communications as additional revenue sources for MNOs. The inflow of foreign capital from global mobile operators can improve a corresponding MNO's cash flow. The amount of huge investments in 3G networks may reduce operating incomes, or may increase the amount of accumulated depreciation.

Estimation Method

The above regression equations are estimated via the application of conventional panel data models, the fixed-effects model (FEM) and the random-effects model (REM). Since mobile prices and mobile subscriptions are determined jointly, SUBS and SUBS² should be treated as endogenous variables. Thus, the estimation of the prices equation is conducted via the combination of the two-stage least-squares (2SLS) or instrumental variable (IV) estimation method with FEM or REM. The Hausman test is applied to confirm which model is appropriate and superior.

VI. Estimation Results

Data and Variables

The primary sources of data used in the analysis are Merrill Lynch's Global Wireless Matrix (GWM), ITU's World Telecommunications Indicators (WTI) and World Bank's World Development Indicators (WDI). Mobile market data are collected from various editions of the GWM, whereas country profile data are compiled from the WTI and the WDI. The time span considered in the study is 1998-2009, which corresponds to the period of the rapid growth and maturation of mobile markets. Data regarding country-specific regulatory policies are sourced from consultant reports and operators' website including IDC EMEA (2002) and Ovum Plc's mobile market reports. The dates of introduction of mobile number portability in European countries are based principally on the European Regulator's Group (2005), whereas those of non-European OECD member states are confirmed using Google searches.

Table 5 provides some summary statistics for all variables. Since the number of countries is 24, the number of observations should be $24 \times 12 = 288$. The number of valid cases for each variable, however, varies as the result of missing values. Accordingly, the panel data used in the study is unbalanced. The meaning of the summary statistics for each variable can be interpreted in a conventional way. For example, the average competition period for all sample countries is 10.49, indicating that the sample countries, on average, experienced the presence of competitive rivalry for 10.49 years.

[Table 5 here]

Estimation Results for HHI Equation

Tables 6-8 reports the estimation results for the three regression equations, specifically results for the preferred models based on the Hausman test. In Table 6, only the results for FEM are reported because the Hausman test statistics are in favor of FEM for all three sample periods. In FEM, the removal of country-specific intercept terms eliminates any time-invariant variable (here, INCUM). Thus, the parameter estimates of INCUM are not provided.¹²

One of the principal findings of the HHI equation is that regulatory policies affected market concentration. All findings are consistent with the *a priori* theoretical expectations. First, all the parameter estimates for NOOP are negatively signed and highly significant, thus implying that the introduction of one more competitor reduced the HHI value by 440-550, all other things being equal. The reported parameter estimate for COMP has a negative sign and is statistically significant for all three sample periods. That is, as a country experienced a longer competition period, it tended to have a less concentrated market structure. The variable LEAD evidences positive and statistically significant parameter estimates as well, indicating that a delay in the entry of latecomers resulted in more concentrated market structure.

¹² In REM, the parameter estimates of INCUM always have a positive sign with their values ranging between 0.017 and 0.028, indicating that the HHI value tended to be higher by 0.017-0.028 (or 170-280) in the countries in which a former fixed telecommunications market incumbent monopoly entered into the mobile market as an incumbent. Careful attention, however, should be paid to this interpretation, as the parameter estimates of INCUM are frequently statistically insignificant and because REM may provide inconsistent parameter estimates.

The parameter estimate of GLOB has a negative sign and is statistically significant in Models 1 and 3, indicating that the presence of global mobile carriers as a competitor resulted in less concentrated market structure. However, this estimate is statistically insignificant in Model 2. Thus, the effect of global mobile carriers on market concentration varies, depending on the sample period under investigation. Finally, at a glance, the finding that the introduction of MNP had no effect on market concentration appears inconsistent with *a priori* expectations. The introduction of MNP, however, might induce price competition in some countries, which favored large MNOs with deep pockets, resulting in more concentrated markets. In other countries, the price competition ignited by the introduction of MNP might favor innovative new entrants. That is, it may be unsurprising that the introduction of MNP exerted no statistically definitive impact on market concentration.

Another interesting finding in Table 6 is that all the parameter estimates for NOOP, COMP, and LEAD decrease from Model 2 to Model 3. In other words, the marginal effect of these regulatory variables on market concentration declined substantially from the first half of the 2000s to the second half of the 2000s. This finding reflects the fact that few significant changes in market shares across MNOs might occur in mature and stabilized mobile markets.

[Table 6 here]

Estimation Results for Profits Equation

In Models 1 and 2 of the profit equations, the variables HHI, CDEN, and INVEST have positive and statistically significant parameter estimates. That is, MNOs tended to have a higher level of profits, as measured by the EBITDA service margin, in countries with more concentrated market structure and a higher cellular density; this is also the case for the period of active 3G investments. The finding that the positive relationship between market concentration and profits is observed in mobile markets, like in many other industries, deserves attention. Additionally, it appears that an increase in the mobile penetration rate contributed to improvements in profitability by activating economies of density. The positive parameter estimate of INVEST reflects the possibility that increased depreciation due to huge investments in 3G networks exceeded reduced operating income. The parameter estimates for GLOB and DSR are always

statistically insignificant. That is, both inflow of foreign capital from the three global mobile carriers and digital subscriptions had no impact on the EBITDA service margin.

The noteworthy finding in Table 7 is that all the parameter estimates, except for HHI, become statistically insignificant in Model 3. Moreover, in Model 3, the significance test (Wald χ^2) does not reject the joint hypothesis that all coefficients are equal to zero. In other words, as mobile markets became mature and stable in the second half of the 2000s, the profits of MNOs tended to be gradually determined by unobservable and/or non-systematic random factors.

[Table 7 here]

Estimation Results for Prices Equation

In the price equations of Table 8, one of the key findings is that the reported parameter estimate for HHI is positively signed and statistically significant in Model 1, with unobservable country-specific factors being controlled for. That is, when the data for the entire period is used, mobile prices tended to be higher in more concentrated market structures, supporting the market-power hypothesis. This positive structure-price relationship implied by the market-power hypothesis, however, is refuted when data for two divided periods is used. The parameter estimate of HHI becomes statistically insignificant in both Models 2 and 3.¹³ Moreover, its sign changes from positive in Model 2 to negative in Model 3. Therefore, a tentative conclusion that the market-power hypothesis is no longer valid at least in the second half of the 2000s can be reached.

The parameter estimate of MNP has a negative sign and is statistically significant in Models 1 and 3, but is statistically insignificant in Model 2. This finding indicates that the effect of MNP was not fully materialized by the first half of the 2000s, but it finally led to a price decline in the second half of the 2000s. The variable RPOPL has positive and statistically significant parameter estimates in all models, implying that higher mobile prices are partly attributable to higher rural

¹³ When REM is applied, the parameter estimate of HHI is positively signed and statistically significant in Model 2, and is still positively signed but statistically insignificant in Model 3. That is, if this finding is true, the market-power hypothesis is applicable in the first half of the 2000s, but is not valid in the second half of 2000s.

population ratio which requires more funds for expansion of coverage. The signs and statistical significance of other parameter estimates vary, depending on the sample period.

[Table 8 here]

V. Conclusions

The study examines the interaction between market concentration, prices, and profit for OECD member state mobile markets using annual panel data from 24 OECD member states for the period 1998-2009. When data for the whole period is used, the results confirm that more concentrated mobile markets led to higher mobile prices and higher profits. This finding supports the market-power hypothesis. On the other hand, in the second half of the 2000s, market concentration had no further effect on mobile prices, whereas the positive relationship between market concentration and profits persisted. In other words, the market-power hypothesis is rejected in the second half of the 2000s. It is possible that the HHI values on the basis of MNO's market share had no meaningful effect on mobile prices because of differing levels of service-based competition at the retail level. Additionally, the results of this study provide evidence that regulatory policies affected mobile market structure and performance.

This empirical result provides a strong case for the recent lenient approach towards regulation and merger attempts in OECD mobile markets. If the positive concentration-price relationship is still valid, regulators should play an important role in protecting or promoting mobile market competition. In particular, regulators should scrutinize a merger of facility-based MNOs, as any substantial reduction of the effective competitor base may result in a diminution of consumer welfare. On the other hand, if the market-power hypothesis were wrong, mergers between competing MNOs would not increase mobile prices. Additionally, lifting regulation on wholesale markets would not hamper competition on the retail markets.

On the other hand, the results of this study do not preclude the role of sector-specific regulation in some countries, as the empirical analysis is based on international comparisons. As indicated previously, the level of competition across OECD member states is uneven. Some

countries may need regulation in mobile markets at present.¹⁴ Clearly, differences in the efficacy of regulation result in differences in competition between countries. Thus, regulators should attempt to ensure that competitive market structure continues to be maintained in the right direction with an appropriate level of competition.

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¹⁴ Some regulators, especially in countries with more concentrated mobile markets, express deep concerns about mobile market competition. For example, the New Zealand Commerce Commission indicated that competition and service quality in the New Zealand mobile sector is still lagging behind, expecting the mobile market competition to improve by the entry of a third mobile operator (Telecomasia.net, April/15/2009). Recently the Korean telecom regulator decided to impose the resale obligations upon the incumbent mobile operator, which are expected to accelerate service-based competition in mobile markets.

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Table 1 Sample means for OECD mobile market indexes

	1999	2001	2003	2005	2007	2009
<i>Market Structure Indexes</i>						
Number of operators	3.04	3.38	3.50	3.38	3.38	3.39
Subscriber-based HHI	4,436	3,985	3,882	3,742	3,656	3,589
Revenue-based HHI			4,011	3,831	3,738	3,650
Incumbent market share	52.7%	48.0%	46.5%	44.4%	43.5%	42.4%
<i>Market Performance Indexes</i>						
RPM (constant USD PPP)	0.382	0.309	0.267	0.215	0.158	0.121
EBITDA margin	27.5%*	32.8%	37.5%	35.3%	34.7%	33.5%
EBITDA service margin			41.2%	39.4%	37.3%	37.1%
Mobile subscriptions per 100 persons	39.6	67.8	80.4	94.8	110.1	122.0
<i>Other Indexes</i>						
Prepaid subscription ratio	52.3%*	57.1%	56.6%	55.0%	50.5%	45.9%
Monthly ARPU (constant USD PPP)	55.7	43.5	40.0	36.0	31.0	26.4
Monthly MOU (minutes)	146.5	135.0	141.8	156.4	172.4	174.6
Monthly churn rate	1.68%*	1.72%	1.67%	1.68%	1.90%	2.16%
Fixed Telephone lines per 100 persons	50.3	50.5	49.4	47.5	44.6	35.2

Note: * indicates that the corresponding statistic is calculated with more than one-third of observations being missing.

Table 2 Groups of OECD Member States by Mobile Market HHI Values, 2009

Range	Subscriber-based HHI value
HHI < 3,000	UK 2,221 (5); Germany 2,843 (4); Poland 2,899 (4), Italy 2,910 (4)
$3,000 \leq \text{HHI} < 3,500$	Austria 3,165 (4); Denmark 3,280 (4); Sweden 3,320 (4); Spain 3,393 (4); Australia 3,446 (3); Finland 3,465 (3); Belgium 3,495 (3)
$3,500 \leq \text{HHI} < 4,000$	Czech Republic 3,519 (3); Greece 3,546 (4); Japan 3,574 (4); Hungary 3,583 (3); Portugal 3,606 (3); Ireland 3,633 (3); France 3,800 (3); Netherlands 3,848 (3); Korea 3,870 (3)
HHI \geq 4,000	Turkey 4,144 (3); Switzerland 4,582 (3); New Zealand 4,621 (3); Norway 5,416 (2)

Note: The number of MNOs is in parentheses. The number of MNOs in Japan includes an independent PHS operator, Willcom. The statistic for Ireland is reported as of 2007 because Ireland data of 2008 and 2009 is not available in Merrill Lynch's Global Wireless Matrix.

Table 3 Regulatory and market characteristics by HHI values, 2009

	HHI < 3,000	3,000 ≤ HHI < 3,500	3,500 ≤ HHI < 4,000	HHI ≥ 4,000
Number of operators	4.25	3.57	3.13	2.75
Competition period	17.0	16.9	16.0	14.5
Lead-time	10.6	13.1	8.6	10.1
Ratio of cases for MNP=1	100.0%	100.0%	100.0%	100.0%
Ratio of cases for INCUM=1	75.0%	85.7%	75.0%	75.0%
Ratio of cases for GLOB=1	100.0%	42.9%	75.0%	75.0%
Operation period	22.0	25.4	22.0	23.8
RPM (constant USD PPP)	0.110	0.104	0.140	0.119
EBITDA margin	33.9%	31.8%	34.2%	34.7%
EBITDA service margin	36.1%	34.9%	38.8%	38.3%
Mobile subscriptions per 100 persons	131.5	130.3	114.3	109.5
Prepaid subscription ratio	63.5%	34.5%	42.1%	55.7%
Monthly ARPU (constant USD PPP)	21.8	24.9	31.0	23.9
Monthly MOU (minutes)	144.5	186.9	175.4	181.8
Monthly churn rate	2.53%	1.97%	2.23%	2.00%
Ratio of data revenues	28.8%	25.3%	24.3%	25.2%

Table 4 Merger activities in OECD mobile markets

Year	Country	Combining MNOs
2000	Korea	KTF (19.7%) – HansolM.com (11.7%)
2001	Italy	Wind (15.5%) – Blu (3.6%)
2002	Korea	SK Telecom (40.9%) – Shinsegi Telecom (11.4%)
2003	Finland	DNA (8.2%) – Telia Finland (6.6%)
2004	Denmark	Telia Denmark (9.5%) – Orange Denmark (11.6%)
2004	Turkey	Avea-TIM (7.8%) – Turk Telecom [Aycell] (7.8%)
2004	USA	Cingular Wireless (19.2%) – AT&T Wireless (17.5%)
2005	Austria	T-Mobile Austria (25.5%) – tele.ring (10.6%)
2005	Netherlands	KPN Mobile (38.0%) – O2 NL [Telfort] (14.4%)
2005	USA	Sprint Corp (12.4%) – Nextel Communications (10.5%)
2007	Greece	TIM Hellas (20.1%) – Q-telecom (7.6%)
2007	Netherlands	T-Mobile NL [Ben] (15.0%) – Orange NL [Dutchtone] (12.0%)
2009	Australia	Hutchison Australia (8.6%) – Vodafone Australia (17.9%)
2010	UK	Orange UK (20.7%) – T-Mobile UK (21.3%)

Note: Only mergers between two competing MNOs are reported. Subscriber-based market shares at the time of mergers are in parentheses. The calculation of market shares in US mobile markets uses data on national carriers.

Table 5 Summary statistics

Name	Description	Cases	Mean	Std dev	Max	Min
Dependent variables						
HHI	Herfindahl-Hirschman index	285	0.395	0.091	1.000	0.222
RPM	RPM (constant USD PPP)	257	0.248	0.131	0.911	0.071
PROF	EBITDA service margin	244	0.373	0.080	0.510	-0.013
Independent variables (telecommunications specific variables)						
NOOP	Number of operators	286	3.297	0.785	5	1
COMP	Competition period (=Years since introduction of competition)	286	10.49	5.15	28	0
LEAD	Lead-time	284	10.22	3.36	17.67	4
MNP	=1, if mobile number portability; =0, otherwise	286	0.587	0.493	1	0
INCUM	=1, if the former fixed monopoly is an incumbent mobile operator; =0, otherwise	286	0.755	0.431	1	0
GLOB	=1, if one of the three global operators are present; =0, otherwise	286	0.696	0.461	1	0
SUBS	Mobile subscriptions (million)	285	23.37	26.11	112.80	0.72
SUBS2	SUBS squared (billion)	285	1.226	2.382	12.723	0.001
CDEN	Mobile subscriptions per one person	285	0.809	0.325	1.559	0.050
DSR	Digital subscriber ratio (=digital / total subscribers)	286	0.984	0.058	1.000	0.249
INVEST	=1, if investments in 3G network were under progress; =0, otherwise					
Independent variables (macro-economic variables)						
PDEN	Population density (thousand persons / square km)	288	0.156	0.136	0.503	0.002
RPOPL	Rural population ratio (=rural / total population)	288	0.261	0.107	0.469	0.026

Table 6 Estimation results for HHI equations

	Model 1: Whole period	Model 2: Period 1998-'04	Model 3: Period 2005-'09
	FEM	FEM	FEM
NOOP	-0.055 ^{***} (0.005)	-0.064 ^{***} (0.007)	-0.044 ^{***} (0.006)
COMP	-0.007 ^{***} (0.001)	-0.012 ^{***} (0.002)	-0.004 ^{***} (0.001)
LEAD	0.005 [*] (0.003)	0.013 ^{***} (0.004)	0.007 ^{***} (0.003)
MNP	-0.008 (0.006)	-0.003 (0.008)	-0.003 (0.006)
GLOB	-0.028 ^{***} (0.008)	0.004 (0.014)	-0.016 ^{**} (0.008)
Constant	0.623 ^{***} (0.019)	0.595 ^{***} (0.025)	0.502 ^{***} (0.020)
No of obs.	284	166	118
R ²	0.660	0.666	0.546
F value	98.9 ^{***}	54.8 ^{***}	21.4 ^{***}
Hausman statistic (χ^2)	24.7 ^{***}	21.8 ^{***}	31.8 ^{***}

Note: Standard errors are in parentheses. FEM refers to fixed-effects model. The number of groups is 24.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table 7 Estimation results for profit equations

	Model 1: Whole period	Model 2: Period 1998-'04	Model 3: Period 2005-'09
	REM	REM	REM
HHI	0.242 ^{**} (0.108)	0.290 [*] (0.151)	0.263 [*] (0.159)
CDEN	0.093 ^{***} (0.019)	0.181 ^{***} (0.044)	-0.019 (0.034)
GLOB	0.004 (0.015)	-0.002 (0.027)	0.017 (0.020)
DSR	-0.002 (0.080)	-0.031 (0.094)	-0.510 (1.002)
INVEST	0.047 ^{***} (0.011)	0.037 ^{**} (0.016)	0.005 (0.018)
Constant	0.190 [*] (0.105)	0.148 (0.137)	0.803 (1.002)
No of obs	242	129	113
R ²	0.145	0.189	0.130
Wald χ^2	40.0 ^{***}	41.5 ^{***}	4.9
Hausman statistic (χ^2)	9.1	6.9	5.5

Note: Standard errors are in parentheses. REM refers to random-effects model. The number of groups is 23.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table 8 Estimation results for price equations

	Model 1: Whole period	Model 2: Period 1998-'04	Model 3: Period 2005-'09
	FEM/IV	FEM/IV	FEM/IV
HHI	0.612 ^{***} (0.135)	0.233 (0.239)	-0.073 (0.302)
SUBS	-0.004 (0.003)	-0.024 ^{***} (0.008)	0.003 (0.008)
SUBS2	0.011 (0.027)	0.215 ^{**} (0.097)	-0.041 (0.048)
MNP	-0.064 ^{***} (0.015)	0.023 (0.022)	-0.063 ^{***} (0.018)
PDEN	0.700 (2.336)	3.615 (3.597)	-8.351 ^{**} (4.167)
RPOPL	2.854 ^{***} (0.760)	3.501 ^{**} (1.724)	4.136 ^{**} (1.722)
Constant	-0.699 (0.453)	-0.978 (0.891)	0.510 (0.669)
No of obs.	238	140	98
R ²	0.692	0.578	0.528
Wald χ^2	4,374.7 ^{***}	3,674.9 ^{***}	3,589.2 ^{***}
Hausman statistic (χ^2)	228.9 ^{***}	58.4 ^{***}	4,748.7 ^{***}

Note: Standard errors are in parentheses. FEM and IV refer to fixed-effects model and instrumental variable estimation method, respectively. The number of groups is 24.

* p < 0.10, ** p < 0.05, *** p < 0.01