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Consumer Switching and Competition Strategy in IT-enabled Markets

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Consumer Switching and Competition Strategy in IT-enabled Markets

A dissertation submitted in partial satisfaction of
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by

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The dissertation of Xiahua Wei is approved, and it is acceptable

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Chair

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DEDICATION

To my family and the University of California, San Diego, who have supported and nurtured my intellectual endeavor.

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ABSTRACT OF THE DISSERTATION

Consumer Switching and Competition Strategy in IT-enabled Markets

by

Xiahua Wei

Doctor of Philosophy in Economics

University of California, San Diego, 2013

Professor Kevin Zhu

My dissertation studies consumer switching and competition in information technology (IT)-enabled markets, using the wireless telecommunications industry as a testing field. The first chapter examines the impact of a public policy, mobile number portability (MNP), on market competition. The second chapter investigates how investment in customer acquisition would affect business performance of wireless

operators, and how the adoption of new technology would complement marketing strategy and enhance firm's competitive advantage. The third chapter analyzes asymmetric effects of MNP across firms and countries.

Chapter 1

Reducing Consumer Switching Costs with Portability: Evidence of Market Competition in the Global Wireless Industry

Abstract

This paper studies the effect of a public policy, Mobile Number Portability (MNP), on market competition in the global wireless telecom industry. To promote competition, the policy intends to reduce consumer switching costs and even the playing field for small firms, but its actual consequences are unclear. We construct an asymmetric duopoly model in which switching costs are heterogeneous across customer segments. The model predicts that the overall market share of the large firm will decrease, while its average price may increase; the effect on the small firm is the opposite. We test these predictions empirically by analyzing panel data of 218 wireless operators in 52 countries over six years. We find relative market share gains for small firms under MNP. Yet, large firms still manage to sustain a higher average price than smaller firms. We call these two contrasting findings “market share convergence” and “price divergence.” By examining customer base composition, we find that large firms are able to retain higher-value

contract subscribers while small firms tend to attract lower-value “pay-as-you-go” subscribers. Contrary to popular belief, even with MNP, large firms continue to dominate. Using MNP as a natural experiment, our study provides insights into pro-competition portability policies in other IT-enabled markets with consumer switching costs, and whether they achieve intended outcomes to promote competition.

1.1 Introduction

> "*You cannot compete effectively in the information economy unless you know how to identify, measure, and understand switching costs and map strategy accordingly*" (Shapiro and Varian 1999, p.133).

Many industries are affected by customer switching. This is particularly important when government regulations are introduced to affect switching costs. For example, portability policies allow consumer information (e.g., bank account, medical record) to be transferrable among service providers. Mobile Number Portability (MNP) is such a policy in the wireless telecom industry.[1] It allows customers to keep their phone numbers when changing operators. Hence, it eliminates the hassle to inform one's social networks (e.g., friends and business contacts), such that the overall switching costs are lower (Gans et al., 2001). MNP has been introduced in 63 countries by April 2011 (ITU, 2011). It was regarded as a driver of open competition and market deregulation (FCC, 2004).

As MNP reduces switching costs, it may allow customers to choose operators that better match their needs, which may in turn lead to market share reallocation among service providers (firms). Yet evidence is mixed about whether or not MNP makes the market more competitive. For example, while market concentration (as measured by Herfindahl-Hirschman Index or HHI) decreased post-MNP in the U.S., it seemed

[1] Among various switching costs, phone numbers not portable is identified as one of the most important factors that prevent customers from switching (Lee et al., 2006; Park, 2007).

unaffected by MNP in Japan, according to data reported by the Global Wireless Matrix (2009).

Understanding such effects will help firms design strategies to better attract and retain customers when switching costs are reduced. Along this line, our study attempts to investigate how MNP might affect market competition, and whether it provides an opportunity for small firms to grab market share from large firms. Specifically, it examines whether customers will flow more in one direction (from larger networks to smaller networks) than the other, what drives the flow, and how the outcome varies under different market conditions.

The existing literature does not offer a consensus on these questions. In the presence of switching costs, market share may either converge (e.g., Farrell and Klemperer, 2007) or tip toward large firms (e.g., Beggs, 1989). It is not obvious which effect will dominate. For example, a study suggests that MNP may actually increase market concentration in Hong Kong (Shi et al., 2006), but it is unclear whether the finding can be generalized to other markets.

If MNP indeed leads to market share reallocation in favor of smaller firms, would this carry on to greater pricing power as well? The answer to this question will help to address a fundamental issue: how do reduced switching costs affect oligopoly pricing?

As MNP is designed to reduce switching costs, we expect that it will affect customer purchase decisions. In the wireless industry, customers are categorized into two segments, i.e., contract versus prepaid customers. They incur different levels of switching costs, and a reduction in switching costs by MNP may affect them differently. Hence, MNP offers us a rare and excellent natural experiment. The same policy shock may produce different impacts on firms whose customer compositions are different.

These issues motivate the following research questions in this study: (1) Does MNP indeed decrease market concentration as switching costs are reduced? (2) Does the price of large and small firms converge as a result of MNP? (3) How does customer composition affect these competitive outcomes between large and small firms?

These questions need to be answered both theoretically and empirically. We first construct a simple game-theoretic model to inform our theoretical understanding of these possible effects and the development of hypotheses. We then conduct an empirical evaluation of the hypotheses. We put greater emphasis on the empirical analysis in this paper.

More specifically, we first build a two-period asymmetric duopoly model. This is used to capture how a reduction in switching costs will affect market shares and prices. We represent customer heterogeneity by segmenting customers based on their switching costs. We also incorporate price discrimination based on purchase history, which reflects a common practice in the telecom industry. The model leads to three hypotheses with respect to our research questions.

We then test them empirically, based on a large panel dataset of 218 major wireless operators in 52 countries over six years (2003-2009). Our findings reveal that MNP does tend to equalize the market shares between large and small firms. That is, we observe “market share convergence.” This effect is more evident in markets with lower concentration. Yet, it does not help smaller firms with pricing power. Indeed, we observe “price divergence” between large and small firms. To explain this contradiction, we probe deeper into firms’ customer base composition. We find that large firms are able to retain more contract subscribers after MNP, while those customers who switch to smaller firms may generally be less valuable prepaid customers.

The rest of the paper is organized as follows. We first provide a literature review related to our research questions. Then we present our analytical model and hypotheses. This is followed by a description of the data, empirical analysis and a discussion of results. We conclude with key findings, implications, limitations and extensions.

1.2 Theoretical Background

Three characteristics are important to the wireless industry and essential to our study: switching costs, customer segmentation, and price discrimination. We review the relevant literature and discuss the industry background, so as to provide guidance for our analytical and empirical models.

1.2.1 Switching Costs, Prices and Market Concentration

Switching costs may lock in customers to a firm. This creates two distinct incentives for the firm. One is to price lower to attract new customers in order to build a larger customer base, i.e., “investing incentive”. The other is to price higher to exploit existing customers, i.e., “harvesting incentive”. The literature shows that in this bargain-and-then-ripoff pattern, the second incentive tends to dominate (e.g., Klemperer 1987a, b; Beggs and Klemperer, 1992). Hence, switching costs may lead to higher prices and decreased competition. This may justify policy interventions, such as number portability, to reduce switching costs and promote competition (e.g., Viard, 2007).

Existing studies on MNP are mainly based on a key theoretical prediction: lower switching costs are associated with more switching, lower prices and greater competition (see Farrell and Klemperer 2007 for a review). Some empirical evidence is consistent with this prediction. For instance, prices decrease after MNP in Korea (Lee et al., 2006) and Hong Kong (Shi et al., 2006).

Yet, the relationship also depends on a firm's market position, i.e., large, dominant incumbent versus small new entrant (Aoki and Small, 1999), among other things. In duopoly models, the dominant position of a firm can generate two opposing effects. On one hand, the larger firm tends to charge higher prices to exploit its existing customers, that is, the "fat-cat" effect (Farrell and Klemperer, 2007). In anticipation of this, customers may choose to buy from the smaller firm. This eventually leads to market share convergence (Klemperer 1987a, b; Farrell and Shapiro, 1988). Initial market asymmetry may persist, but it will be dampened over time (Taylor, 2003).

On the other hand, larger firms may be able to retain dominance through switching costs. A larger network has more customers, and is able to provide a wider variety of services. Hence, it is more valuable to customers. This "top-dog" effect can be magnified through positive-feedback dynamics, which can lead to tipping towards market dominance (Beggs, 1989; Dubé et al. 2005).

With these opposing effects, it is not clear whether a decrease in switching costs by MNP would achieve the intended outcome. By comparing market shares two quarters before and two quarters after MNP in Hong Kong, Shi et al. (2006) observe that large firms became larger after MNP. While this finding is interesting, the time horizon may be too short to reveal the real effect. Another concern is its generalization beyond one region/country. Market characteristics differ significantly across countries, for example, in terms of market concentration and growth rate. Hence, "careful empirical studies across different countries are needed" to validate the conditions and predictions of the model (Shi et al. 2006, p.35). We seek to narrow this gap.

1.2.2 Customer Segmentation: Contract versus Prepaid Customers

Traditional economic models predict that switching costs tend to raise prices (e.g., Farrell and Shapiro, 1988). Hence, we expect reduced switching costs, such as by MNP, to decrease prices. Furthermore, this effect seems to depend on the relative composition of the customer segments with different switching costs: contract customers and prepaid customers, in the wireless industry. Wireless operators often attempt to lock in customers through service contracts.[2] If customers switch away during the contract period, they usually have to pay early termination fees. On the contrary, customers can purchase "pay-

[2] Industry reports show that the average contract length is 1-2 years (OECD Communications Outlook 2009; Business Monitor International 2010).

as-you-go" prepaid calling cards without any contractual obligation. All else being equal, contract customers incur additional "contractual switching costs";[3] they are also usually large-volume users who have more social contacts, and thus incur higher "social network switching costs" if phone numbers are not portable. Therefore, contract customers overall have higher switching costs. When its percentage of contract customers rises, a firm's average switching costs are higher; this strengthens its harvesting incentive. Hence, we conjecture that firms with a higher percentage of contract customers may be associated with higher prices, even after MNP.

1.2.3 Price Discrimination: Paying Customers to Switch

"Paying customers to switch" is a common practice to discriminate between firms' own customers and the rivals' customers (Chen, 1997). Indeed, wireless operators usually offer free minutes, lower introductory rates, handset subsidies, and waiving of activation fees. This strategy of price discrimination is recognized as "customer poaching" (Fudenberg and Tirole, 2000; Gehrig *and* Stenbacka, 2004).

Mainly, there are two types of models on price discrimination by purchase history. First, *ex ante* homogeneous products become *ex post* differentiated by uniformly distributed switching costs (Taylor, 2003). The results resemble the bargain-and-then-ripoff pattern in classic switching costs models, while the second-period equilibrium prices are independent of the first-period market share. The second type uses Hotelling

[3] According to Klemperer (1987a), there are mainly three types of switching costs: transaction costs (e.g., locked handsets), learning costs, and artificial/contractual switching costs (e.g., service contracts).

model of *ex ante* product differentiation, without switching costs in the second period (Fudenberg and Tirole, 2000; Villas-Boas, 1999). As customers expect to be likely poached by a rival in the second period, the first-period demand becomes less elastic. This makes the first-period prices higher than in the static model.

The features of both models are relevant to our research setting. First, cellular service is not homogenous, but horizontally differentiated.[4] Second, wireless customers have different switching costs, even in the same segment. Therefore, we model heterogeneous switching costs in addition to *ex ante* product differentiation. We expect the tradeoff between investing and harvesting, and the equilibrium second-period prices to depend on the first-period market share.

1.3 Model

Based on the discussion above, we develop a two-period asymmetric duopoly, which extends the canonical switching costs models (e.g., Klemperer, 1987a) to the case with price discrimination and customer segmentation. The model serves as a vehicle to examine the directions of change in market shares and prices due to switching costs reduction by MNP, so that we can derive hypotheses about the possible persistence of the large firm's dominance.

[4] For instance, some operators have loyalty programs (e.g., rolled-over minutes), and provide exclusive handsets; customers may be heterogeneous in their brand preferences.

1.3.1 The Model Setup

Consider a market with a continuum of customers normalized to 1. They are served by two firms *a* and *b*, whose respective initial market shares are σ_0^a and σ_0^b , where $\sigma_0^a + \sigma_0^b = 1$. Assume that firm *a* is larger (the dominant firm), i.e. $\sigma_0^a > \sigma_0^b$ (or $0.5 < \sigma_0^a \leq 1$). We introduce this *ex ante* asymmetry as it is more realistic than the usual symmetry assumption in the literature. Further, σ_0^a can be used as a proxy for the initial market structure, as a greater σ_0^a means that the market is more asymmetrically concentrated toward the larger firm. This allows us to study the MNP effect on different firms under different market structures.

The market consists of two segments: high- and low-switching costs customers (abbreviated as segment *H* and segment *L*), corresponding to contract and prepaid users respectively in the wireless market. Assume the share of segment *H* is u $(0 < u < 1)$, and that of segment *L* is $(1-u)$. We use a Hotelling model with horizontal differentiation. Customers of each segment are uniformly distributed on [0, 1], and the two firms are located at the two ends of this unit interval. Firms are assumed to have the same marginal cost, which is normalized to 0 for simplicity.

Each customer has unit demand, and a utility *V* from consumption of the service. We assume *V* is the same for all customers, and sufficiently large so that they all will buy. A customer located at x_i of segment *i* has a distance x_i of buying from *a* and $(1-x_i)$ from *b*. The unit transportation cost is α_i .

The two firms compete in price in two periods. In the first period, both firms simultaneously announce their prices, and then customers purchase from either firm. In the second period, firms observe the purchase decisions of all customers, and give a discount to customers who switch away from the rival.

We define price as the subscription price in each period. It is the per-period total price a customer pays for a service plan. We denote p_{it}^{j} as firm *j*'s price in period *t*, and m_i^j as firm *j*'s discount to its new customers in period 2 (*i* =*H*, *L; j* =*a* or *b*; *t* =1, 2).

Customers in segment *i*, if they switch, will incur switching costs, which are segment-specific and uniformly distributed on $[0, \theta_i]$. Assume customer preference heterogeneity is independent of switching costs, and remains stable over time (Shin and Sudhir 2009). Assume customers switch only within the same segment, not across segments. For example, in the second period in segment *i*, if an existing customer of firm *a* located at x_i^a is indifferent between staying with *a* and switching to *b*, then her net utility is

$$V - \alpha_i x_i^a - p_{i2}^a = V - \alpha_i (1 - x_i^a) - p_{i2}^b + m_i^b - s_i \qquad (i = L \text{ or } H)$$

Similarly, firm *b*'s indifferent customer in segment *i* is characterized by the net utility:

$$V - \alpha_i (1 - x_i^b) - p_{i2}^b = V - \alpha_i x_i^b - p_{i2}^a + m_i^a - s_i \qquad (i = L \text{ or } H)$$

Such indifferent customers determine a new allocation of market share, consisting of loyal customers and those switching from the rival. Denote the market share in segment *i* at the end of period *t* as σ_{it} and $1-\sigma_{it}$ for firm *a* and *b*, respectively (*i* =*H* or *L*; *t*=1, 2).

We make two other assumptions about switching costs. First, customers in segment *H* on average incur higher switching costs than those in segment *L*, i.e., $\theta_H > \theta_L$. Second, MNP reduces switching costs equally in both segments; switching costs in segment *H* remain higher than *L* after MNP.

1.3.2 Analyses and Hypotheses

We use backward induction to solve the equilibrium prices and market shares, and focus on the second period results. All mathematical derivations are provided in the Appendix.

First, we are interested in whether the second-period equilibrium market share of firms would converge after MNP. We calculate the overall equilibrium market share of each firm, and their difference as:

$$\Delta\sigma^* = \sigma_2^{a*} - \sigma_2^{b*} = u\Delta\sigma_{H2}^* + (1-u)\Delta\sigma_{L2}^*$$

where $\Delta\sigma_{i2}^* = \sigma_{i2}^{a*} - \sigma_{i2}^{b*}$. If MNP is effective in reducing the larger firm's market share, we should expect $\Delta\sigma^*$ to decrease. Comparative statics show that:

$$\frac{\partial\Delta\sigma^*}{\partial\theta_i} > 0$$

Therefore, $\Delta\sigma^*$ becomes smaller as θ_i decreases after MNP. Hence, the large firm will lose market share to the small firm. We call this "market share convergence" hereafter. In addition, the extent of market share convergence is decreasing in σ_0, the initial market share asymmetry:

$$\frac{\partial\Delta^2\sigma^*}{\partial\theta_i\partial\sigma_0} < 0$$

That is, if the initial market share is highly concentrated towards the dominant firm, it converges less. This result leads to our first hypothesis:

Hypothesis 1 (H1). *A reduction in switching costs induced by MNP will narrow the gap between market shares of the large and small firms. This effect is more evident in markets with lower concentration.*

Second, we examine the equilibrium average prices and their difference between firms. Firm *j*'s average price in segment *i* is

$$\bar{p}_{i2}^{j*} = p_{i2}^{j*}q_{i2}^{jj*} + (p_{i2}^{j*} - m^{j*})q_{i2}^{jk*}$$

where q_{i2}^{jj*} is the number of its loyal customers, and q_{i2}^{jk*} is the number of new customers acquired from firm *k*. Then the average price for firm *j* (*j*=*a* or *b*) is:

$$\bar{p}^{j*} = \frac{u\sigma_{H2}^{j*}\bar{p}_{H2}^{j*} + (1-u)\sigma_{L2}^{j*}\bar{p}_{L2}^{j*}}{u\sigma_{H2}^{j*} + (1-u)\sigma_{L2}^{j*}}$$

This measure is the average (weighted over segments) of the average price (weighted over old/new customers).

Define the difference in average price between firms as $\Delta\bar{p}^{*} = \bar{p}^{a*} - \bar{p}^{b*}$. It can be shown that:

$$\frac{\partial(\Delta\bar{p}^{*})}{\partial\theta_H} < 0 \text{ and } \frac{\partial(\Delta\bar{p}^{*})}{\partial\theta_L} > 0.$$[5]

It means that when switching costs are lowered by MNP, the gap of average price increases in segment *H* but decreases in segment *L*. Further, when $\left|\frac{\partial(\Delta\bar{p}^{*})}{\partial\theta_H}\right| > \left|\frac{\partial(\Delta\bar{p}^{*})}{\partial\theta_L}\right|$, a decrease in switching costs by MNP will widen the price gap between the large and small firms. Moreover, this effect may increase with the size of segment *H*. Intuitively, when there are more customers in this segment, the large firm may have stronger harvesting incentive to exploit their switching costs with a higher price, and thus compete less aggressively after MNP. This result leads to our second hypothesis.

Hypothesis 2 (H2). *A reduction in switching costs induced by MNP will increase the price gap between large and small firms; this effect increases with the segment of contract customers.*

Up to this point, our hypotheses are about the *overall* market share and *average* price for firms aggregated over two segments. Next, we further examine how market share and price change in *each* segment, so as to better understand the underlying mechanism that drives the aggregate outcome.

[5] See Appendix (A42)-(A44).

First, we examine market share. In segment i (i = H or L), the difference in market share between firms a and b is:

$$\Delta\sigma_{i2}^{*} = \sigma_{i2}^{a*} - \sigma_{i2}^{b*} = \alpha_i^{-1}\left[A^{-1} + \frac{2}{3}\left(\theta_i - \frac{\alpha_i}{3} - \frac{\alpha_i^2}{3\theta_i}\right)\right]$$

A change in switching costs θ_i will affect this measure as follows:

$$\frac{\partial(\Delta\sigma_{i2}^{*})}{\partial\theta_i} > 0.$$

Hence, when θ_i decreases as a result of MNP, the market share gap is expected to decrease as well. In other words, the small firm becomes larger, and market share converges in both segments.

Now consider the difference in average prices between the firms in segment *H:*

$$\Delta\overline{p}_{H2}^{*} = \overline{p}_{H2}^{a*} - \overline{p}_{H2}^{b*}$$

A change in switching costs suggests that:

$$\frac{\partial\overline{p}_{H2}^{a*}}{\partial\theta_H} < 0 \text{ and } \frac{\partial\overline{p}_{H2}^{b*}}{\partial\theta_H} > 0 \text{.}$$ [6]

Hence, the combined effect is:

$$\frac{\partial\Delta\overline{p}_{H2}^{*}}{\partial\theta_H} < 0 \text{.}$$

[6] See Appendix (A36).

When switching costs decrease due to MNP, the price gap is expected to widen in segment *H*. The large firm is in a better position to charge higher price than the small firm.

Similarly, the price gap in segment *L* is:

$$\Delta\overline{p}_{L2}{}^{*} = \overline{p}_{L2}^{a*} - \overline{p}_{L2}^{b*}$$

It can be shown that both firms reduce prices in *L* in response to lower switching costs, i.e.,

$$\frac{\partial \overline{p}_{L2}^{a*}}{\partial \theta_L} > 0 \text{ and } \frac{\partial \overline{p}_{L2}^{b*}}{\partial \theta_L} > 0 .$$[7]

Meanwhile, the small firm can charge an even lower price when the second effect dominates. In this case, the net effect suggests $\frac{\partial \Delta\overline{p}_{L2}^{*}}{\partial \theta_L} < 0$. Therefore, when θ_L becomes lower after MNP, the small firm competes more aggressively, increasing the price gap.

In sum, our model predicts that the market share will converge and prices will diverge in both segments, but through different mechanisms: market share converges in segment *L more* than in *H*; the large firm decreases price in *L* but increases price in *H*. Although losing some market share, the large firm enhances its pricing power and increases average price. Further, by letting go some *L* customers but retaining more *H* customers, the proportion of high-switching costs customers is expected to increase in the large firm's customer base. In contrast, the market share gained by the small firm mainly

[7] See Appendix (A39).

comes from segment *L*; lower price in this segment drive down its average price. This result leads to our final hypothesis:

Hypothesis 3 (H3). *A reduction in switching costs induced by MNP will increase (decrease) the percentage of contract customers for the large (small) firm, contributing to its higher (lower) average price.*

Overall, our analysis suggests that MNP's effect should be reflected in both market share and average price. These effects may be asymmetric across firms, depending on the initial market concentration and customer segments.

1.4 Data and Variables

To test the above theoretical predictions, we conduct an empirical evaluation. We obtained three primary datasets. The first is a firm-level quarterly panel dataset of 218 major wireless operators over 6 years (2003Q1-2009Q2) in 52 countries from the Global Wireless Matrix. During the sample period, 30 countries had MNP in effect.[8] The variables used in this study include *subscriber market share*, average subscription price

[8] In the sample, 17 countries/regions introducing MNP during the sample period: Austria, Brazil, Canada, Czech, Finland, France, Greece, Hungary, Japan, South Korea, Mexico, New Zealand, Pakistan, Singapore, South Africa, Taiwan and the U.S.; 13 other countries/regions had already introduced MNP before the sample period. The time of MNP introduction is identified at quarter level. Source comes from Electronic Communications Committee Report 31 (2005), and regulators in individual markets.

(*Price*), percentage of contract customers (*Contract Subs%*), and percentage of data revenue in total revenue (*Data Rev%*). Further, we calculate the industry-level HHI based on subscriber market shares.

To control for industry- and country-level heterogeneity, we use a complementary dataset from the Global Market Information Database.[9] The variables include: the number of cellular phones per 100 inhabitants (*Cellular Penetration*), cellular growth rate (*Growth Rate*)[10], substitute/complementary services such as *Fixedline Telephone Penetration* and *Internet Penetration*, GDP per capita (*GDP*), as well as demographics variables such as population density, and the percentages of age groups 13-19 (*Teen*), 20-29 (*Young*), 30-49 (*Mid-age*), and people with college and above degrees (*HiEdu*).

The third dataset is the Worldwide Governance Indicators (WGI) from the World Bank.[11] We obtain indicators of institutional governance, including government effectiveness (*Gov Effectiveness*) and regulatory quality (*Regulate Quality*). In countries with more effective regulation, MNP is more likely to be introduced. Another related indicator is "voice and accountability" (*Voice*). It measures "the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media," according to WGI. These

[9] All country-level data are yearly; we use linear interpolation to obtain quarterly data.

[10] It is defined as the percentage change of subscribers from the previous quarter (t-1) to the present quarter (t).

[11] The WGI "compiles and summarizes information from 30 existing data sources that report the views and experiences of citizens, entrepreneurs, and experts in the public, private and NGO sectors from around the world, on the quality of various aspects of governance."

indicators range from -2.5 to 2.5, and higher values means better governance or rule of law.

Summary statistics are reported in Table 1 for the following: (1) the full sample, (2) subsample 1, 30 countries with MNP by the end of the sample period, and (3) subsample 2, 17 countries introducing MNP only during the sample period.[12] For all panels, a simple mean comparison shows that HHI decreases after MNP (significant at the 1% level). This seems to suggest that the market becomes more competitive. However, we cannot tell whether the change is attributed to MNP or the general time trend, or both. Also, this only reports the average change and does not show how the change may differ across firms and countries. Hence, a more rigorous analysis is needed.

To reduce the scale effect of prices across countries, we also calculate the percentage change of average price (*Price % Change*). The trend before MNP shows that the average quarterly change is 0.73% decrease in *Price% Change*, and 0.64% increase in *Data Rev*%. After MNP, *Price* and *Data Rev*% seem to increase in all samples, while the *Price* increase slows down. When we restrict to subsamples 1 and 2, *Price % Change* seems to decrease more evidently; *Contract Subs%* is stable around 50-60% over time.

For country-level variables, the cellular penetration rises and market growth slows down as the industry matures. Hence, the increase of *Cellular Penetration* and the decrease of *Growth Rate* after MNP are possibly due to the time trend. The three

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[12] Country-level socioeconomic variables are not reported in the interest of space, but are available upon request.

governance indicators also demonstrate an increasing trend, indicating better governance over time.

1.5 Empirical Analysis

1.5.1 MNP and Market Concentration at the Industry Level

We first estimate the effect of MNP on *market concentration* measured by HHI at the industry level. For country *k* at time *t*, its HHI is estimated as a function of MNP in a dynamic panel data model:

$$HHI_{kt} = \alpha + \beta_1 MNP_{kt} + \beta_2 MNP_{kt} * Z_{kt} + Z'_{kt}\phi + W'_{kt}\varphi + \gamma_t + \omega_k + \varepsilon_{kt},$$

where MNP_{kt} is a dummy variable which equals 1 if MNP is introduced at time *t* for country *k* and 0 otherwise; Z_{kt} controls industry characteristics (initial market concentration $HHI_{k(t-1)}$, *Penetration*, *Growth Rate*, *Contract Subs%*), and W_{kt} represents socioeconomic controls; γ_t subsumes quarterly dummy, seasonality and country-specific time trends; ω_k is country fixed effect; and ε_{kt} is the error term not captured by the regressors.

Regression (1) constitutes a difference-in-difference model. The key variable of interest is MNP. As an industry regulation mandate, MNP can be regarded as an exogenous policy shock. Meanwhile, MNP introduction could be possibly affected by the capacity of the government to pass regulations; such institutional factors may also affect market competition. To reduce potential omitted variables bias, we first include variables related to MNP regulation: *Gov Effectiveness* and *Regulatory Quality*. Further, we instrument MNP by "voice and accountability" (i.e., *Voice*). In countries with greater freedom of expression, consumers' voice can be heard more easily, and policies in their best interests, such as MNP, are more likely to be passed. For instance, in the U.S. many consumer advocates, such as the Consumers Union, successfully urged the FCC to pass MNP.[13] Meanwhile, it is not obvious that this variable would affect wireless market concentration directly.[14] Therefore, this time-variant variable can potentially explain a shift in MNP introduction. The correlation between MNP and *Voice* is 0.64; the coefficient of *Voice* on MNP in the first-stage regression is significantly positive (1% level), and the F-statistic and R^2 are reasonably high.[15] Therefore, *Voice* can serve as an instrumental variable.

The inclusion of a lagged dependent variable in (1) also introduces possible endogeneity. Hence, we apply the Arellano-Bond Generalized Method of Moments (GMM) estimation (Arellano and Bond 1991) to control for endogeneity, i.e., we use the past value of explanatory variables as instruments for the lagged dependent variable.[16] This method also corrects for heteroskedasticity and tests for autocorrelation in residuals.

[13] "Our campaign on wireless number portability was such a success because it gave voice to tens of thousands of consumers frustrated with poor cell phone service quality, who forced the carriers to listen. Our mission is to continue providing that very powerful voice." Press Release, Consumers Union, January 6, 2004.

[14] For countries that introduced MNP during the sample period, the mean of *Voice* is 0.824, and standard deviation is 0.713 at the time of MNP. This variable changes over time and has an increasing trend.

[15] F (35, 49) =3.96, and the significance level is 1%; R^2 =0.83.

[16] The second and third lags are used as instruments.

The over-identification tests in Table 2 verify the model specification and estimation. We transform Eq.(1) through first differencing to remove the unobserved heterogeneity.[17]

We first restrict $\beta_2 = 0$ (i.e., without the interaction effects), so as to focus on the direct effect. The first parameter of interest is β_1. According to H1, if MNP is effective in balancing market share, we should expect β_1 to be negative.

The estimation results confirm this prediction. As shown in Table 2, HHI decreases on average by 0.022 (or 7.5%) after MNP.[18] Given that the quarterly change in HHI before MNP is a slight decrease of 0.001, the magnitude of its reduction due to MNP is substantial. This suggests that markets on average become more competitive due to MNP, which supports H1.

The coefficient on lagged HHI represents the speed of the market concentration adjustment. It is significantly positive, suggesting that markets with higher concentration tend to continue to be concentrated in the next period.

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[17] Eq.(1) can be estimated by fixed effects or first differencing transformation. First differencing is more efficient than fixed effects if there is serial correlation (Woodridge, 2002).

[18] This is the average effect of MNP. To capture possible time patterns of the MNP effect, we replace the original single MNP indicator by 11 mutually exclusive dummies indicating the time relative to MNP: 1-3 quarters before MNP, the quarter with MNP introduction (omitted reference category), 1-6 quarters after MNP, and beyond. We find that the negative effect is the strongest in the 5th lagged quarter and then levels off. It is plausible that many customers are not aware of the availability of MNP when it is first implemented. Therefore, it takes time for the effect to become prominent.

The coefficient on cellular penetration is significantly negative. When the market gets saturated and the industry matures, price competition may be further intensified, making market share more equally distributed among firms. The coefficient on growth rate is significantly negative too, suggesting that fast growing markets tend to become less concentrated, because the flow of new customers can help dilute concentration. The coefficient on contract subscribers percentage is positive (significant for the two subsamples), confirming the role of contracts as a lock-in device. But its impact on industry concentration is modest, especially if the time horizon is extended longer, as in the full sample. Robustness checks on subsamples 1 and 2 are mostly consistent (Columns 2 and 3, respectively). The marginal effect of MNP is stronger in subsample 2 than subsample 1.

To estimate how the MNP effect varies under different market conditions, we now include the interaction terms between MNP and market concentration, penetration, growth rate, and contract subscribers percentage (i.e., $\beta_2 \neq 0$). The estimation results for the full sample are in Table 2, Column 4. The direct effect of $HHI_{k(t-1)}$ is significantly positive as before, indicating the robustness of the model. We expect that MNP would help reverse this trend, yet the positive interaction term seems to strengthen the effect instead. This implies that MNP is not going to be effective in highly concentrated markets.

We find that MNP strengthens the negative effect of growth rate on HHI (especially in subsample 2). In markets with large inflows of new customers, firms may have stronger investing incentive to compete more aggressively, leading to lower concentration. When MNP is introduced to such markets, it may drive the average switching costs even lower. This helps to equalize market shares among firms. This implies that MNP is more effective in fast growing markets.

Finally, the marginal effect of MNP, evaluated at the sample means of other variables, is significantly negative, i.e., HHI decreases by 0.019 (or 4.7%) after MNP. This again supports H1.[19] Robustness checks on subsamples 1 and 2 are mostly consistent. The interaction term between MNP and *Contract Subs*% becomes significant in subsample 2, which confirms the importance of contract lock-in in relatively short terms. Given that the results of the subsamples are mostly consistent, but the full sample is more efficient, we report the full sample results in all subsequent analyses.[20]

1.5.2 MNP and Market Share at the Firm Level

If MNP decreases market concentration at the industry level as found above, we should expect similar evidence at the firm level. That is, market shares of large firms will decrease after MNP, while those of small firms will increase, thus reducing market concentration.

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[19] As robustness checks, we use two alternative market concentration measures, i.e., the coefficient of variation of market shares, and the gap between the largest and the smallest market shares in each country. The results are consistent.

[20] We also perform robustness checks with subsamples analysis in each section. The results are similar to the full sample (available upon request).

To test this, we specify a regression model of market shares as below. The choice of explanatory variables is based on our analytical solutions for the equilibrium market share, including switching costs (MNP) and initial market concentration:

$$\sigma_{ikt} = \alpha_1 + \beta_1 \sigma_{ik,t-1} + \beta_2 MNP_{kt} + \beta_3 MNP_{kt} * Z_{kt} + Z'_{kt}\phi + W'_{kt}\varphi + \gamma_t + \eta_i + u_k + \varepsilon_{ikt},$$

where the dependent variable σ_{ikt} is the market share of firm *i* in country *k* at time *t*, $\sigma_{ik,t-1}$ is its lag; Z_{kt}, W_{kt} and γ_t are defined the same as before; η_i and u_k capture unobservable firm- and country-fixed effects, respectively, which are allowed to be correlated with Z_{kt}, W_{kt} and MNP_{kt}; ε_{ikt} is the error term not captured by the regressors, which has zero conditional mean $E[\varepsilon_{ikt} \mid MNP_{kt}, W_{kt}, Z_{kt}, \eta_i, u_k, \gamma_t] = 0$, under the assumption that it is uncorrelated with the regressors in each period after controlling for unobserved firm- and time-invariant heterogeneity.

MNP is reasonably believed to be an exogenous policy shock. Meanwhile, firms may have some influence over the regulation. For instance, large firms usually argue against MNP, concerned about losing customers. They may lobby the government, thus influencing the policy implementation. To address possible endogeneity, we instrument MNP as in the previous industry-level analysis.

We first separate “large firms” and “small firms”. We label “large firms” as those with the highest market share (above 50%), or the largest two firms with combined market share greater than 50% before MNP in a country, and the rest are “small firms”. Summary statistics in Table 3 show that these two groups have systematic differences before and after MNP. For example, market shares of large firms decrease substantially after MNP, while those of the small firms increase (row 1). This is consistent with the industry-level evidence. *Average price* seems to increase after MNP for both groups, but *Price % Change* has opposite directions. This alerts us that the large firms may be able to keep up with increasing prices, while the small firms may be under greater pressure to reduce price when the competition intensifies. Also, *Contract Subs%* increases for large firms after MNP, while decreases for small firms. *Data Rev%* increases more for large firms. Overall, the preliminary evidence indicates that the effects on large and small firms are rather asymmetric, which we will further analyze in Section 5.4.

Then we estimate Eq.(2) for large and small firms, respectively, using GMM estimation. Results are reported in Table 4. We find that the market share of large firms indeed *decreases* (the negative coefficient on MNP in row 1), while that of small firms *increases* (1% level). This means that *small firms* tend to gain market share as a result of MNP.

The coefficient on *lagged HHI* is negative for large firms but positive for small firms, implying a decreasing trend of market concentration, which is healthy. Yet this effect is reversed by MNP, as indicated by the interaction effects. Furthermore, the coefficient on *Growth Rate* is negative for large firms, which agrees with the previous industry-level result. In the presence of MNP, this effect is stronger for large firms, which implies that new customers are mainly flowing toward small firms, thus reducing large firms' market shares. Therefore, the introduction of MNP tends to dampen the oligopolistic power of large firms, especially in fast-growing markets.

In addition, the coefficient on *Contract Subs*% is positive for large firms, highlighting the lock-in effect of contracts to large firms (even after MNP). In contrast, for small firms the effect of *Contract Subs*% is not significant, possibly due to the weaker network effects.

Overall, the marginal effects of MNP (third row from bottom in Table 4) show that it *reduces* a typical large firms' market share by 4.7% (about 11,988 customers), while *increasing* a typical small firms' market share by 5% (about 2,915 customers). Hence, the magnitude of the market share reallocation is substantial.

To summarize, our findings at the firm level are consistent with those at the industry level. That is, MNP tends to work in favor of small firms. The effect is more evident in markets with lower concentration. It follows that policymakers should take into consideration the timing of MNP introduction in order for it to be effective.

1.5.3 MNP and Average Price

We now look into the relationship between MNP and firms' average price (H2). In our data, the average price (*Price*) is defined as the per-period subscription price of a service plan, which is consistent with our analytical model. We use the percentage change of *Price* (*Price % Change*) as the dependent variable. This eliminates scale effects of prices across countries. To control for other non-MNP factors and the time trend, we include those variables from our analytical model (switching costs, initial market share and contract customer percentage), as well as a lagged dependent variable:

$$p_{ikt} = \alpha_1 + \beta_1 p_{ik,t-1} + \beta_2 MNP_{kt} + \beta_3 MNP_{kt} * Z_{kt} + Z'_{kt}\phi + W'_{kt}\varphi + \gamma_t + u_i + \mu_k + \varepsilon_{ikt}$$

where p_{ikt} is the *Price % Change* of firm *i* in country *k* at time *t*, $p_{ik,t-1}$ is its lag, and all other variables are defined the same as before. We estimate Eq.(3) for all firms, and large and small firms respectively. The results are reported in Table 5.

On average, MNP tends to reduce *Price % Change*. This consequence may not have been anticipated by policymakers. Furthermore, the percentage of contract customers contributes positively and significantly to the average price increase. The effect is further strengthened, as opposed to be weakened, by MNP, especially for large firms, as the coefficient of the interaction term is positive. This is consistent with H2: contract subscribers can still help enhance large firms' pricing power, even with MNP.

The coefficient on *lagged HHI* is negative for small firms. This suggests that small firms have to charge lower prices in highly concentrated markets dominated by large firms. Unfortunately, MNP does not seem to change this, as the interaction term remains negative (column 3). It means that concentration really hurts small firms in terms of pricing power, and this is still true even with MNP. Large firms are still capable of charging high prices in concentrated markets. While this sounds counter-intuitive, large firms may have already developed sophisticated strategies to retain customers, or they may have become large because of their superior quality or broad network coverage. MNP may prove to be insufficient to change this. This sounds like bad news to policy makers, but is consistent with our earlier finding that large firms tends to remain large in more concentrated markets. An implication follows that the pro-competition policy should be introduced before the "800 lb gorilla" becomes too large. Countries that have not implemented MNP may need to act timely.

In addition, the coefficient on *Growth Rate* shows that for small firms, higher growth rate is associated with lower prices. They tend to price aggressively to build up customer base; this "investing incentive" is more evident with large inflows of new customers. Also, this negative effect is strengthened by MNP, and the extent is greater than that of large firms. In contrast, large firms tend to exploit existing customers (most on contracts); fortunately this "harvesting incentive" is reversed by MNP.

Overall, prices are lower with MNP for small firms, but higher for large firms. As indicated by the marginal effect, the *Price % Change* of large firms *increases* 0.6% (equivalent to 6.7% increase in price) after MNP, while that of small firms *decreases* 3.5% (equivalent to 10.3% decrease in price). This may seem contradictory: although their market shares decline due to MNP, large firms seem to be able to charge higher prices.

In summary of Sections 1.5.1-1.5.3, MNP has opposite effects on market share and price. The market share reallocation in favor of small firms does not necessarily translate into greater pricing power. Then we have two interesting but opposite findings: "market share convergence" and "price divergence." This raises an important question. Why, when switching costs decrease, are large firms still able to sustain higher pricing power? We next test H3, in hope of making sense of this conundrum.

1.5.4 MNP and Customer Base Composition

Our H3 suggests that customer composition may help explain the asymmetric effects on small and large firms. Price sensitivity varies across customer segments (Danaher et al., 2008), and industry evidence shows that contract customers are more profitable than prepaid customers (e.g., FCC, 2004-2009). Hence, *a priori*, contract subscribers are more valuable than prepaid customers. Indeed, this is confirmed in our results below.

First, recall that the sample mean of large firms' *Contract Subs%* increases after MNP, while that of small firms' decreases (Table 3). Furthermore, a difference-in-difference regression confirms this pattern (the left panel in Table 6), which supports H3. On average, the *Contract Subs%* increases by 6.9% for large firms after MNP, while decreases by 1.7% for small firms. It seems to imply that large firms are able to attract and retain high-value contract subscribers (corresponding to segment *H* in our model). In contrast, the increase in market share of small firms comes from low-value prepaid subscribers (corresponding to segment *L* in our model).

Second, data and voice services are subscribed by customers with different willingness to pay (Niculescu and Whang, 2011). If large firms retain more customers from segment *H*, who are more likely to use data service, we should also expect the percentage of data revenue to increase more for the large firms. This conjecture is confirmed when we use *Data Rev*% as the dependent variable in the difference-in-difference regressions (the right panel in Table 6). *Data Rev*% increases by 2% for large firms after MNP, while it does not change significantly for small firms. This provides further evidence to support H3.

These results can be reconciled with customer segmentation as we have analyzed in our theoretical model. Large firms may have more inframarginal customers (contract subscribers) than small firms, and therefore are willing to lose some marginal customers (prepaid subscribers) in segment L and focus more on segment H. When switching costs are reduced by MNP, it becomes more important to focus on retaining those customers with higher switching costs and willingness to pay. MNP facilitates customer switching, but *it does not guarantee that the firms gaining more customers will be better off.* It depends on what kinds of customers are switching, and whether firms can retain customers in segment H. This finer-grained analysis demonstrates that managing customer segments plays an important role in firms' strategy, and identifying what customers to retain is a key issue. Our result brings in important implications for firms in the presence of policy shocks, especially for small players.

1.6 Concluding Remarks

Switching costs are prominent characteristics of customer-centric, technology-intensive industries such as telecommunications, banking, and digital services. They are strategically important in managing customer behavior and formulating business strategy, particularly when government policies regulate these costs. A case in point is portability policies, which are designed to level the playing field by allowing consumer information portable and thus reducing switching costs. Yet, do such policies indeed help promote market competition? Do small players have an opportunity to acquire a larger slice of the pie and gain greater pricing power? We use the wireless industry as a testing field to investigate these questions. The fact that MNP was introduced in different countries at different times, and to different market structures, provides us with a rare but excellent natural experiment to pursue this goal.

To inform our study, we first construct a two-period asymmetric duopoly model that illustrates some key features of our research setting: switching costs, product differentiation, customer segmentation, and price discrimination in the wireless industry. Our model provides insight into how a decrease in switching costs would affect market shares and prices of large and small firms. Based on the analytical results, we derive three hypotheses and then devote our major efforts on empirical analysis. In particular, we investigate the impact of MNP on the persistence of dominant oligopoly, and whether MNP can reverse the dominance by facilitating the growth of small firms. This contributes to the understanding of how portability policies may alter firms' ability to compete, and how firms should adjust their strategies to better retain customers.

This paper has limitations and leaves several issues open for future research. In our analytical model, the market is assumed to be fully covered. In reality, new customers may continue to enter the market. They incur no switching costs. As the new segment becomes large, firms' investing incentive may outweigh the harvesting incentive, hence lowering the average price. Meanwhile, as long as the new segment is not too large, we expect our qualitative conclusions to hold. Furthermore, we did not have separate data about the voice and data services of specific plans. As data services become more prominent in 3G or 4G era, future studies should estimate how this new trend would affect our results. Finally, while we only have average prices data, it would be further informative to analyze prepaid and contract prices separately. This would require more extensive data.

Withholding these limitations, our analysis and findings have the following features. First, analytically we model heterogeneity on both the demand side (consumer switching costs) and supply side (asymmetric market position), and identify market segmentation as a critical factor in competing in technology-intensive industries under regulation. Customers are categorized into two groups based on the magnitude of their switching costs. Also, we introduce price discrimination based on purchase history and horizontal differentiation into the switching costs model. These features help reveal the *asymmetric effects* of the policy shock on dominant and non-dominant firms, and highlight the importance of customer segmentation to understanding switching costs.

Second, we incorporate the analytical model into empirical testing. This integrated methodology contributes to the literature, which calls for more empirical evidence to validate theoretical predictions. Our empirical analysis focuses on the change in both market concentration and price in response to policy shocks. We find *convergence* in market share and *divergence* in average price between large and small firms. Although the portability policy helps reallocate market share in favor of small firms, large firms are still in a better position to retain more of those customers who incur higher switching costs but also generate greater value, and let go those low-value, price-sensitive customers. This highlights that what customers to retain becomes an issue with greater strategic importance when switching costs are lower.

Third, our unique global datasets allow us to account for various market conditions in an international context. We find that the portability act may be more effective in markets that have low concentration and are still growing. This kind of insight is absent in smaller-scale studies on individual markets. This also adds to the literature that has mixed empirical evidence about MNP effects in different countries. We believe that the present cross-country study may have greater external validity.

Fourth, this paper offers several managerial and policy implications. On one hand, MNP may open up opportunities to attract new customers, and the potential to increase loyalty of existing subscribers. For instance, firms can defend their market share by various lock-in activities and loyalty programs. Alternatively, firms may need to improve their customer services or increase their efforts to provide better products so as to retain valuable customers. On the other hand, MNP can bring a challenge. As reported earlier, portability facilitates customer switching, but it does not guarantee that the firms gaining more customers will be better off. It depends on whether firms can retain the right kind of customers. Small firms in particular can gain market share through attractive pricing, but it may be very costly or even back fire. Hence, identifying what customers to retain is a key issue. Firms should manage customer segments more carefully; strategies geared toward retaining higher value customers become even more important in the presence of a pro-competition policy.

From a policy perspective, our finding offers new insights into MNP effects that might be unexpected by industry regulators. MNP should be gauged carefully at the firm level, so as to evaluate its real impact on the competition, especially on small firms. The results also provide implications for the timing of MNP introduction. For example, it seems more effective to introduce the policy at early stage while the market is still growing and has not been stuck with a sticky oligopolistic equilibrium controlled by a few “800 lb gorillas.”

Overall, this paper helps unknot the asymmetric effects of MNP in a global context, and provides insights into how to manage customer switching in the presence of regulation policies. Although this study is conducted in the context of the wireless industry, our approach is applicable to the analysis of change in switching costs in other industries as well, such as personal data portability in online communities, digital services, the banking industry, and the healthcare industry as electronic medical records become more widely adopted. We hope the efforts reported in this paper will help stimulate more research in this growing area.

1.7 Appendix: Equilibrium Analysis

We start the analysis on customer segment *i* by backward induction.

Second Period

At the beginning of period 2, firm *a* and *b* have market share from period 1: σ_{i1} and $1-\sigma_{i1}$, respectively. After firms announce prices and discounts, customers make purchase decisions. If an existing customer of firm *a* located at x_i^a is indifferent between staying at *a* and switching to *b*, then

$$V-\alpha_i x_i^a - p_{i2}^a = V-\alpha_i(1-x_i^a)-p_{i2}^b+m_i^b-s_i \tag{A1}$$

Similarly, firm *b*'s indifferent customer is characterized by

$$V-\alpha_i(1-x_i^b)-p_{i2}^b = V-\alpha_i x_i^b - p_{i2}^a + m_i^a - s_i \tag{A2}$$

This identifies indifferent customers in segment *i*:

$$s_i^a(x_i^a)=\alpha_i(2x_i^a-1)+p_{i2}^a-p_{i2}^b+m_i^b \tag{A3}$$

$$s_i^b(x_i^b)=\alpha_i(1-2x_i^b)+p_{i2}^b-p_{i2}^a+m_i^a \tag{A4}$$

We assume that the location of the indifferent customer is at an interior *x* for all θ: $s_i^a(0)\ge 0,\ s_i^b(1)\ge 0,\ s_i^a(x_i^a)\in[0,\sigma_{i1}]$, and $s_i^b(x_i^b)\in[1-\sigma_{i1},1]$. This condition will be checked after optimal solutions are derived.

Let q_{jk} represents the number of customers who bought from firm *k* in period 1 and now buys from firm *j* in period 2. Then firm *a*'s loyal customers in segment *i* are

$$q_{aa}^i=\int_0^{\sigma_{i1}}\left(\int_{\alpha_i(2x_i^a-1)+p_{i2}^a-p_{i2}^b+m_i^b}^{\theta_i}\frac{1}{\theta_i}ds\right)dx=\frac{\sigma_{i1}}{\theta_i}\left[\theta_i+\alpha_i\left(1-\sigma_{i1}\right)-p_{i2}^a+p_{i2}^b-m_i^b\right] \tag{A5}$$

Hence, firm a's customers in segment *i* who switch to firm *b* are

$$q_{ba}^i=\frac{\sigma_{i1}}{\theta_i}\left(\alpha_i\sigma_{i1}-\alpha_i+p_{i2}^a-p_{i2}^b+m_i^b\right) \tag{A6}$$

Similarly, firm *b*'s loyal customers are

$$q_{bb}^{i}=\int_{\sigma_{i1}}^{1}\left(\int_{\alpha_i(1-2x_i^b)+p_{i2}^b-p_{i2}^a+m_i^a}^{\theta_i}\frac{1}{\theta_i}ds\right)dx=\frac{1-\sigma_{i1}}{\theta_i}\left(1-p_{i2}^b+p_{i2}^a-m_i^a+\alpha_i\sigma_{i1}\right)\qquad\text{(A7)}$$

and customers switching away are

$$q_{ba}^{i}=\frac{1-\sigma_{i1}}{\theta_i}\left(p_{i2}^b-p_{i2}^a+m_i^a-\alpha_i\sigma_{i1}\right)\qquad\text{(A8)}$$

Therefore, firm *a*'s total market share in segment *i* becomes

$$\sigma_{i2}^{a}=q_{i2}^{aa}+q_{i2}^{ab}=\sigma_{i1}+\frac{1}{\theta_i}\left[p_{i2}^b-p_{i2}^a+m_i^a-\left(m_i^a+m_i^b\right)\sigma_{i1}\right]\qquad\text{(A9)}$$

and firm *b*'s market share is

$$\sigma_{i2}^{b}=q_{i2}^{bb}+q_{i2}^{ba}=1-\sigma_{i1}+\frac{1}{\theta_i}\left[\left(m_i^a+m_i^b\right)\sigma_{i1}-p_{i2}^b+p_{i2}^a-m_i^a\right]\qquad\text{(A10)}$$

Firm *j* maximizes its second period profit from customers buying from it in both periods, and those switching from its competitor *k* (*j*, *k* = *a* or *b*).

$$\max_{(p_{i2}^j,m_i^j)}\pi_{i2}^{j}=p_{i2}^{j}q_{i2}^{jj}+(p_{i2}^{j}-m_i^{j})q_{i2}^{jk}\qquad\text{(A11)}$$

Substitute q_{i2}^{jj} and q_{i2}^{jk} into the objective function and solve for first order conditions, we have equilibrium prices and discounts in the second period:

$$\begin{aligned}p_{i2}^{a*}&=2\theta_i/3+\alpha_i(1-\sigma_{i1})/3\\p_{i2}^{b*}&=2\theta_i/3+\alpha_i\sigma_{i1}/3\\m_i^{a*}&=m_i^{b*}=(\theta_i+\alpha_i)/3\end{aligned}\qquad\text{(A12)}$$

Then the effective poaching prices are

$$\begin{aligned}\lambda_i^{a*}&=p_{i2}^{a*}-m_i^{a*}=(\theta_i-\alpha_i\sigma_{i1})/3\\\lambda_i^{b*}&=p_{i2}^{b*}-m_i^{b*}=[\theta_i-(1-\alpha_i)\sigma_{i1}]/3\end{aligned}\qquad\text{(A13)}$$

Further, the equilibrium market shares are

$$\begin{aligned}\sigma_i^{a*}&=q_{i2}^{aa*}+q_i^{ab*}=(1+\sigma_{i1})/3\\\sigma_i^{b*}&=q_{i2}^{bb*}+q_i^{ba*}=(2-\sigma_{i1})/3\end{aligned}\qquad\text{(A14)}$$

Substituting the above optimal prices into the second-period profit, we have

$$\pi_{i2}^{a} = \frac{\sigma_{i1}}{\theta_i}\left[2\theta_i/3 + \alpha_i(1-\sigma_{i1})\right]^2 + \frac{1-\sigma_{i1}}{\theta_i}\left[(\theta_i - \alpha_i\sigma_{i1})/3\right]^2,$$
$$\pi_{i2}^{b} = \frac{1-\sigma_{i1}}{\theta_i}\left[2\theta_i/3 + \alpha_i\sigma_{i1}\right]^2 + \frac{\sigma_{i1}}{\theta_i}\left[(\theta_i/3 - \alpha_i(1-\sigma_{i1})/3\right]^2. \tag{A15}$$

Hence, the second-period profit is a function of first period market shares.

First Period

At the beginning of period 1, firm *a* and *b* have market share σ_{i0} and $1-\sigma_{i0}$, respectively. Assume there is no price discrimination in the first period, and consumers incur switching costs if they switch. Firms set prices with anticipation of second-period outcome derived above. Assume there is no discount factor for both firms and customers.

Identify indifferent customers and derive firm *a*'s first period market share in segment *i:*

$$\sigma_{i1}^{a} = \frac{\sigma_{i0}}{\theta_i}\left[\theta_i - \left(p_{i1}^{a} - p_{i1}^{b}\right) + \left(\lambda_i^{a} - \lambda_i^{b}\right)\right] + \left[1 - 2\sigma_{i0} + \frac{\sigma_{i0}}{\theta_i}\left[\theta_i - \left(p_{i1}^{b} - p_{i1}^{a}\right) + \left(\lambda_i^{a} - \lambda_i^{b}\right)\right]\right] \tag{A16}$$

Substituting the second period poaching prices derived before, which are functions of σ_{i1}, we solve

$$\sigma_{i1}^{*} = \frac{\theta_i + \sigma_{i0}[2(p_{i1}^{b} - p_{i1}^{a}) + 2\alpha_i/3 - \theta_i]}{\theta_i + 4\alpha_i\sigma_{i0}/3} \tag{A17}$$

Firm *a* maximizes its total profit of both periods in segment *i* by choosing p_{i1}^{a}:

$$\max_{p_{i1}^{a}} \pi_i^{a} = \frac{\sigma_{i1}}{\theta_i}\left[2\theta_i/3 + \alpha_i(1-\sigma_{i1})/3\right]^2 + \frac{1-\sigma_{i1}}{\theta_i}\left[(\theta_i - \alpha_i\sigma_{i1})/3\right]^2 + p_{i1}^{a}\sigma_{i1} \tag{A18}$$

Substitute σ_{i1}^{*} and take the first order condition, we have

$$p_{i1}^{a*} = \frac{[\theta_i + \sigma_{i0}(2p_{i1}^{b} + 2\alpha_i/3 - \theta_i)]C - AB}{2\sigma_{i0}C - A} \tag{A19}$$

where $A = -\dfrac{2\sigma_{i0}}{\theta_i + 4\alpha_i\sigma_{i0}/3}$, $B = -\dfrac{1}{9}(2\alpha_i + 3\theta_i + \alpha_i^2/\theta_i)$, and $C = \dfrac{1 - 2\alpha_i A/9(2 + \alpha_i/\theta_i)}{\theta_i + 4\alpha_i\sigma_{i0}/3}$.

Similarly, we can solve for firm *b*'s price in period 1:

$$p_{i1}^{b*} = \frac{1+Ab-[\theta_i+\sigma_{i0}(2\alpha_i/3-2p_{i1}^{a}-\theta_i)]C}{2\sigma_{i0}C+A} \tag{A20}$$

where $b = -\frac{1}{9}(2\alpha_i + \alpha_i^2/\theta_i - 3\theta_i)$.

Solving the above two equations simultaneously, we have

$$\begin{aligned} p_{i1}^{a*} = A^{-2}\{&(A+2\sigma_{i0}C)[AB-C(\theta_i+\sigma_{i0}(2\alpha_i/3-\theta_i)] \\ &-2\sigma_{i0}C[1+Ab-C(\theta_i+\sigma_{i0}(2\alpha_i/3-\theta_i)]\} \end{aligned} \tag{A21}$$

$$\begin{aligned} p_{i1}^{b*} = A^{-2}\{&(A-2\sigma_{i0}C)[1+Ab-C(\theta_i+\sigma_{i0}(2\alpha_i/3-\theta_i)] \\ &-2\sigma_{i0}C[C(\theta_i+\sigma_{i0}(2\alpha_i/3-\theta_i)-AB]\} \end{aligned} \tag{A22}$$

We then substitute the first period prices to solve the second period prices, as well as the first/second period market shares.

To summarize, the first period market share of each firm is

$$\begin{aligned} \sigma_{i1}^{a*} &= \sigma_{i1}^{*} = \frac{\theta_i+\sigma_{i0}(2/A+\theta_i/3+2\alpha_i/9-4\alpha_i^2/9\theta_i)}{\theta_i+4\alpha_i\sigma_{i0}/3} \\ \sigma_{i1}^{b*} &= \frac{\sigma_{i0}(10\alpha_i/9+4\alpha_i^2/9\theta_i-2/A-\theta_i/3)}{\theta_i+4\alpha_i\sigma_{i0}/3} \end{aligned} \tag{A23}$$

The second period market share is

$$\begin{aligned} \sigma_{i2}^{a*} &= \frac{2\theta_i+\sigma_{i0}\left[2\left[A^{-1}+\frac{2}{3}\left(\theta_i-\frac{\alpha_i}{3}-\frac{\alpha_i^2}{3\theta_i}\right)\right]+2\alpha_i-\theta_i\right]}{3\theta_i+4\alpha_i\sigma_{i0}} \\ \sigma_{i2}^{b*} &= \frac{\theta_i+4\alpha_i\sigma_{i0}-\sigma_{i0}\left[2\left[A^{-1}+\frac{2}{3}\left(\theta_i-\frac{\alpha_i}{3}-\frac{\alpha_i^2}{3\theta_i}\right)\right]+2\alpha_i-\theta_i\right]}{3\theta_i+4\alpha_i\sigma_{i0}} \end{aligned} \tag{A24}$$

The second period prices are

$$\begin{aligned} p_{i2}^{a*} &= \frac{2\theta_i}{3}+\frac{\alpha_i\sigma_{i0}}{3\theta_i+4\alpha_i\sigma_{i0}}\left(\frac{10\alpha_i}{9}+\frac{4\alpha_i^2}{9\theta_i}-\frac{2}{A}-\frac{\theta_i}{3}\right) \\ p_{i2}^{b*} &= \frac{2\theta_i}{3}+\frac{\alpha_i}{3\theta_i+4\alpha_i\sigma_{i0}}\left[\theta_i+\sigma_{i0}\left(\frac{2}{A}+\frac{\theta_i}{3}+\frac{2\alpha_i}{9}-\frac{4\alpha_i^2}{9\theta_i}\right)\right] \end{aligned} \tag{A25}$$

In addition, we derive the condition that indifferent customers are at an interior x for all levels of θ, i.e., $s_i^a(0)\ge 0$, $s_i^b(1)\ge 0$, $s_i^a(\sigma_i^*)\le\theta_i$, and $s_i^b(1-\sigma_i^*)\le\theta_i$, which leads to

$$\theta_i \geq 2\alpha_i \tag{A26}$$

It suggests that switching costs are sufficiently high (at least twice as much as transportation costs). In the wireless industry, this means that switching costs outweigh brand preference.

Comparative Statics: Market Share

We focus on the second period equilibrium, and analyze how a decrease in switching costs would affect market share difference and price difference between the large and small firm.

The overall market share of firm *j* is aggregated over two segments

$$\sigma_2^{j*} = u\sigma_{H2}^{j*} + (1-u)\sigma_{L2}^{j*}, \quad (j = a \text{ or } b) \tag{A27}$$

The difference in the overall market share between firms is

$$\Delta\sigma^* \stackrel{def}{=} \sigma_2^{a*} - \sigma_2^{b*} = u\Delta\sigma_{H2}^* + (1-u)\Delta\sigma_{L2}^* \tag{A28}$$

Specifically, we demonstrate the market share in each segment. For segment *H*, the difference in market share between firms is

$$\Delta\sigma_{H2}^* = \sigma_{H2}^{a*} - \sigma_{H2}^{b*} = \alpha_H^{-1}\left[A^{-1} + \frac{2}{3}\left(\theta_H - \frac{\alpha_H}{3} - \frac{\alpha_H^2}{3\theta_H}\right)\right] \tag{A29}$$

We can show that

$$\frac{\partial(\Delta\sigma_{H2}^*)}{\partial\theta_H} = \alpha_H^{-1}\left[\frac{1}{2\sigma_{H0}} + \frac{2}{3}(1 + \frac{\alpha_H^2}{3\theta_H^2})\right] > 0 \tag{A30}$$

This suggests when switching costs decrease, the difference in market shares between firms will be smaller, i.e., market share converges. Further, this convergence effect is stronger when the dominant firm has less initial advantage in size:

$$\frac{\partial^2(\Delta\sigma_{H2})}{\partial\theta_H\partial\sigma_{H0}} = -\frac{1}{2\alpha_H\sigma_{H0}^2} < 0 \tag{A31}$$

An implication is that MNP is more effective when introduced to less concentrated markets.

Similarly, for segment *L*, we can show the small firm gains market share after the policy, i.e., market share converges and becomes more balanced between firms:

$$\frac{\partial(\Delta\sigma_{L2}^{*})}{\partial\theta_L} > 0, \quad \frac{\partial^2(\Delta\sigma_{L2})}{\partial\theta_L\partial\sigma_{L0}} < 0 \tag{A32}$$

In sum, it follows that

$$\frac{\partial\Delta\sigma^{*}}{\partial\theta_H} > 0, \quad \frac{\partial\Delta\sigma^{*}}{\partial\theta_L} > 0 \tag{A33}$$

As MNP decreases θ, we expect the gap between the overall market share of firms will become smaller, i.e., the large firm will lose market share to the small firm; this effect is stronger in less concentrated markets.

Further, the convergence effect in segment *H* is greater than *L* if

$$\frac{\alpha_H}{\alpha_L} < \left[\frac{1}{2\sigma_{L0}} + \frac{2}{3}\left(1+\frac{\alpha_L^2}{3\theta_L^2}\right)\right] \Big/ \left[\frac{1}{2\sigma_{H0}} + \frac{2}{3}\left(1+\frac{\alpha_H^2}{3\theta_H^2}\right)\right] \tag{A34}$$

Comparative Statics: Prices

We first examine firm *a*'s second period price in segment *H*:

$$p_{H2}^{a*} = \frac{2\theta_H}{3} + \frac{\alpha_H\sigma_{H0}}{3(\theta_H + 4\alpha_H\sigma_{H0}/3)}\left(\frac{10\alpha_H}{9} + \frac{4\alpha_H^2}{9\theta_H} - \frac{2}{A} - \frac{\theta_H}{3}\right) \tag{A35}$$

We can show that $\frac{\partial p_{H2}^{a*}}{\partial\theta_H} < 0$ when

$$\frac{\alpha_H\sigma_{H0}}{2(\theta_H + 4\alpha_H\sigma_{H0}/3)^2}\left[\sigma_{H0}^{-1} + \frac{1}{3} + \frac{4\alpha_H^2}{9\theta_H^2} + \sigma_{H0}\left(\frac{10\alpha_H}{9} + \frac{4\alpha_H^2}{9\theta_H} - \frac{2}{A} - \frac{\theta_H}{3}\right)\right] > 1 \tag{A36}$$

As the second period discount is $m_H^{a*} = (\theta_H + \alpha_H)/3$, we have $\frac{\partial m_H^{a*}}{\partial\theta_H} > 0$. Hence, when switching costs are lower, firms will give a smaller discount to attract new customers, as they are more inclined to switch. Together, $\frac{\partial\lambda_H^{a*}}{\partial\theta_H} < 0$, i.e., the effective poaching price $\lambda_H^{a*} = p_{H2}^{a*} - m_H^{a*}$ will become higher in response to reduced switching costs. That is, the large firm will raise its price charged to rival's customers.

For firm a's loyal customers and acquired new customers, we can show that $\frac{\partial q_{H2}^{aa*}}{\partial \theta_H} > 0$, $\frac{\partial q_{H2}^{ab*}}{\partial \theta_H} > 0$. This implies that when switching costs decrease, it becomes harder to retain and poach customers.

We are interested in firm a's average price over all of its customers in segment H: $\bar{p}_{H2}^{a*} = p_{H2}^{a*} q_{H2}^{aa*} + (p_{H2}^{a*} - m^{a*}) q_{H2}^{ab*}$. According to the analysis above, it follows that $\frac{\partial \bar{p}_{H2}^{a*}}{\partial \theta_H} < 0$ under the condition of A(36). Hence, a reduction in switching costs can make the large firm increase its price in segment H.

Second, when it comes to firm b's second period price

$$p_{H2}^{b*} = \frac{2\theta_H}{3} + \frac{\alpha_H}{3\left(\theta_H + 4\alpha_H \sigma_{H0}/3\right)} \left[\theta_H + \sigma_{H0} \left(\frac{2}{A} + \frac{\theta_H}{3} + \frac{2\alpha_H}{9} - \frac{4\alpha_H^2}{9\theta_H} \right) \right] \quad \text{(A37)}$$

we can show that

$$\frac{\partial p_{H2}^{b*}}{\partial \theta_H} = \frac{2}{3} + \frac{\alpha_H}{3\left(\theta_H + 4\alpha_H \sigma_{H0}/3\right)^2} \left[\theta_H + \frac{8\alpha_H^2 \sigma_{H0}}{9\theta_H} + \frac{22\alpha_H \sigma_{H0}}{9} + \frac{4\alpha_H \sigma_{H0}^2}{3} \left(\frac{1}{3} + \frac{4\alpha_H^2}{9\theta_H} \right) - \frac{2\sigma_{H0}}{A} \right] > 0 \quad \text{(A38)}$$

Hence, when switching costs decrease, the small firm will lower its prices as well.

Again, since the second period discount is $m_H^{b*} = (\theta_H + \alpha_H)/3$, we have $\frac{\partial m_H^{b*}}{\partial \theta_H} > 0$. It is easy to show that when switching costs reduce, the price decreasing effect is greater than the discount decreasing effect. Therefore, for the small firm's poaching price $\lambda_H^{b*} = p_{H2}^{b*} - m_H^{b*}$, we have $\frac{\partial \lambda_H^{b*}}{\partial \theta_H} > 0$. This means the small firm will lower its price to attract rival's customers in response to switching costs reduction.

Similarly, it becomes harder to retain its existing customers and poach rival's customers: $\frac{\partial q_{H2}^{bb*}}{\partial \theta_H} > 0$, $\frac{\partial q_{H2}^{ba*}}{\partial \theta_H} > 0$. Firm b's average price over all of its customers in segment H is $\bar{p}_{H2}^{b*} = p_{H2}^{b*} q_{H2}^{bb*} + (p_{H2}^{b*} - m^{b*}) q_{H2}^{ba*}$. According to the analysis above, we can show that $\frac{\partial \bar{p}_{H2}^{b*}}{\partial \theta_H} > 0$. Hence, a reduction in switching costs can make the small firm decrease its price in segment H.

Next, we repeat the above analysis on segment L, and show that (i) $\frac{\partial \bar{p}_{L2}^{a*}}{\partial \theta_L} > 0$ when

$$\frac{\alpha_L \sigma_{L0}}{2\left(\theta_L + 4\alpha_L \sigma_{L0}/3\right)^2}\left[\sigma_{L0}^{-1} + \frac{1}{3} + \frac{4\alpha_L^2}{9\theta_L^2} + \sigma_{L0}\left(\frac{10\alpha_L}{9} + \frac{4\alpha_L^2}{9\theta_L} - \frac{2}{A} - \frac{\theta_L}{3}\right)\right] < 1 \qquad \text{(A39)}$$

and (ii) $\frac{\partial \bar{p}_{L2}^{b*}}{\partial \theta_L} > 0$.

Both firms reduce prices in L in response to lower switching costs. Meanwhile, the large firm can still charge a higher price as long as the following condition holds:

$$\frac{8\alpha_L \sigma_{L0}}{9}\left(1 + \frac{\alpha_L}{\theta_L}\right) - \frac{4\sigma_{L0}}{A} > \theta_L\left(1 + \frac{2\sigma_{L0}}{3}\right) \qquad \text{(A40)}$$

Finally, we consider the overall weighted average price for firm j (j = a or b):

$$\bar{p}^{j*} = \frac{u\sigma_{H2}^{j*}\bar{p}_{H2}^{j*} + (1-u)\sigma_{L2}^{j*}\bar{p}_{L2}^{j*}}{u\sigma_{H2}^{j*} + (1-u)\sigma_{L2}^{j*}} \qquad \text{(A41)}$$

Define the difference in average price between firms as $\Delta\bar{p}^* \overset{def}{=} \bar{p}^{a*} - \bar{p}^{b*}$. The effect of switching costs on $\Delta\bar{p}^*$ through segment H is

$$\frac{\partial(\Delta\bar{p}^*)}{\partial\theta_H} = \left(\frac{u}{1-u}\right)\left[\frac{\frac{\partial E^*}{\partial\theta_H}(p_H^{a*} - p_L^{a*}) + \frac{E^*}{6}\left(1 + \frac{u}{1-u}A^*\right)}{\left(1 + \frac{u}{1-u}E^*\right)^2} + \frac{\frac{F^*}{6}\left(1 + \frac{u}{1-u}B^*\right) - \frac{\partial F^*}{\partial\theta_H}(p_H^{b*} - p_L^{b*})}{\left(1 + \frac{u}{1-u}F^*\right)^2}\right] \qquad \text{(A42)}$$

where $E^* = \sigma_H^{a*}/\sigma_L^{a*}$, $F^* = \sigma_H^{b*}/\sigma_L^{b*}$. It can be shown that $\frac{\partial(\Delta\bar{p}^*)}{\partial\theta_H} < 0$ if

$$2\alpha_L(1 + \sigma_{L0}) > \theta_L, \text{ and } 2(\alpha_H - \alpha_L)(1 + \sigma_{H0}) > \theta_H \qquad \text{(A43)}$$

The effect of MNP on $\Delta\bar{p}^*$ through segment L is

$$\frac{\partial(\Delta\bar{p}^*)}{\partial\theta_L} = \left(\frac{u}{1-u}\right)\left[\frac{\left(\frac{u}{1-u}\right)\frac{\partial E^*}{\partial\theta_L}(p_H^{a*} - p_L^{a*}) + \frac{1}{6}\left(1 + \frac{u}{1-u}E^*\right)}{\left(1 + \frac{u}{1-u}E^*\right)^2} + \frac{\frac{1}{6}\left(1 + \frac{u}{1-u}F^*\right) - \left(\frac{u}{1-u}\right)\frac{\partial F^*}{\partial\theta_L}(p_H^{b*} - p_L^{b*})}{\left(1 + \frac{u}{1-u}F^*\right)^2}\right]$$

(A44)

It can be shown that $\frac{\partial(\Delta\bar{p}^*)}{\partial\theta_L} > 0$ under the following conditions:

$$\begin{aligned} &2\alpha_L(1+\sigma_{L0}) > \theta_L \\ &\left(\frac{u}{1-u}\right)\frac{\partial E^*}{\partial\theta_L}(p_H^{a*} - p_L^{a*}) + \frac{1}{6}\left(1+\frac{u}{1-u}E^*\right) > 0 \end{aligned} \tag{A45}$$

Further, when $\left|\frac{\partial(\Delta\bar{p}^*)}{\partial\theta_H}\right| > \left|\frac{\partial(\Delta\bar{p}^*)}{\partial\theta_L}\right|$ we expect the first effect dominates, i.e., the average price difference between firms widens.

Table 1.1 Descriptive Statistics

	(1) Full Sample				(2) Subsample 1				(3) Subsample 2			
	Overall	Before	After	Obs	Overall	Before	After	Obs	Overall	Before	After	Obs
Firm-level Variables												
Market Share	0.261	0.263	0.258	4809	0.251	0.233	0.258	2928	0.240	0.233	0.245	1738
	(0.171)	(0.183)	(0.154)		(0.164)	(0.189)	(0.154)		(0.173)	(0.189)	(0.157)	
Price ($)	27.770	19.591	37.015	4161	35.260	30.559	37.016	2682	33.764	30.559	36.639	1542
	(16.874)	(15.148)	(13. 644)		(15.241)	(18.051)	(13.644)		(16.884)	(18.051)	(15.211)	
Price % Change †	-0.007	-0.006	-0.008	2072	-0.003	0.011	-0.008	2568	-0.004	0.011	-0.016	1476
	(0.114)	(0.143)	(0.072)		(0.085)	(0.113)	(0.072)		(0.095)	(0.113)	(0.076)	
Contract Subs% †	0.415	0.317	0.527	4060	0.530	0.539	0.527	2594	0.586	0.539	0.625	1499
	(0.309)	(0.007)	(0.262)		(0.289)	(0.354)	(0.262)		(0.330)	(0.354)	(0.301)	
Data Rev% †	0.158	0.144	0.168	2776	0.158	0.124	0.168	2142	0.145	0.124	0.161	1127
	(0.083)	(0.003)	(0.068)		(0.074)	(0.084)	(0.068)		(0.081)	(0.084)	(0.076)	
Country-level Variables												
Cellular Market												
HHI	0.359	0.379	0.334	1260	0.345	0.374	0.334	742	0.350	0.374	0.331	417
	(0.099)	(0.111)	(0.074)		(0.085)	(0.105)	(0.074)		(0.091)	(0.105)	(0.072)	
Cellular Penetration †	0.737	0.534	0.999	1273	0.899	0.634	0.999	743	0.791	0.634	0.925	418
	(0.376)	(0.334)	(0.239)		(0.298)	(0.275)	(0.239)		(0.308)	(0.275)	(0.269)	
Growth Rate †	0.056	0.083	0.023	1209	0.030	0.048	0.023	713	0.034	0.048	0.022	401
	(0.082)	(0.093)	(0.048)		(0.053)	(0.061)	(0.048)		(0.046)	(0.061)	(0.023)	
Governance Indicators												
Gov Effectiveness	0.707	0.158	1.444	1300	1.277	0.857	1.444	750	1.054	0.857	1.232	425
	(0.715)	(0.858)	(0.569)		(0.706)	(0.833)	(0.569)		(0.766)	(0.833)	(0.652)	
Regulatory Quality	0.643	0.105	1.366	1300	1.205	0.800	1.366	750	0.985	0.800	1.152	425
	(0.675)	(0.848)	(0.453)		(0.604)	(0.735)	(0.453)		(0.657)	(0.735)	(0.527)	
Voice & Accountability	0.494	-0.005	1.164	1300	0.999	0.584	1.164	750	0.796	0.584	0.987	425
	(0.658)	(0.799)	(0.498)		(0.641)	(0.764)	(0.498)		(0.705)	(0.764)	(0.585)	

Standard deviations are in parentheses. “Before” and “After” represent before MNP and after MNP, respectively.
† Variables are in raw numbers, not percentage formatted.
Subsample 1 includes 30 countries that had introduced MNP by the end of the sample period.
Subsample 2 includes 17 countries introduced MNP only during the sample period; it is a subset of subsample 1.

Table 1.2 Market Concentration Index (HHI) as Dependent Variable

	Model (1)			Model (2)		
	Full Sample	Subsample 1	Subsample 2	Full Sample	Subsample 1	Subsample 2
MNP	-0.022*	-0.018*	-0.026*	-0.023***	-0.020*	-0.027**
	(0.013)	(0.011)	(0.014)	(0.010)	(0.012)	(0.014)
Lagged HHI	0.301***	0.627***	0.457***	0.794***	0.815***	0.799***
	(0.026)	(0.036)	(0.042)	(0.024)	(0.020)	(0.029)
Penetration	-0.124***	-0.223***	-0.194***	-0.004	-0.015	-0.019***
	(0.028)	(0.016)	(0.033)	(0.012)	(0.012)	(0.003)
Growth Rate	-0.158***	-0.142***	-0.089***	-0.107***	-0.091***	-0.051***
	(0.016)	(0.010)	(0.028)	(0.019)	(0.021)	(0.011)
Contract Subs%	0.035	0.151*	0.215*	0.002	0.022	0.003
	(0.069)	(0.089)	(0.126)	(0.006)	(0.031)	(0.002)
MNP*Lag HHI				0.060***	0.034***	0.049***
				(0.016)	(0.012)	(0.011)
MNP*Pen				0.006	0.012**	0.019***
				(0.008)	(0.005)	(0.005)
MNP*Growth				-0.045	-0.059	-0.027***
				(0.043)	(0.045)	(0.009)
MNP*Contract%				0.005	0.000	0.006**
				(0.006)	(0.006)	(0.002)
Marginal Effect Of MNP	-0.022* (0.013)	-0.018* (0.011)	-0.026* (0.014)	-0.019*** (0.006)	-0.017** (0.009)	-0.025*** (0.009)
Observations	1168	712	400	1152	703	391
Over-identification Test	Chi2(77)= 14.3 Prob>Chi2 =1.0	Chi2(87)= 0.0 Prob>Chi2 =1.0	Chi2(98)= 0.0 Prob>Chi2 =1.0	Chi2(73)= 8.9 Prob>Chi2=0.9	Chi2(85)= 0.0 Prob>Chi2 =1.0	Chi2(96)= 0.0 Prob>Chi2 =1.0

Dependent variables in all regressions are HHI. All estimations are based on GMM.

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.

All regressions include quarterly dummy, seasonality, country-specific time trends, and country fixed effects. These coefficients are not reported here.

Other coefficients not reported: *Gov Effectiveness*, *Regulatory Quality*, *GDP per capita*, *Population Density*, *Cellular*/*Fixed/Internet Penetration*, *Teen*, *Young*, *Mid-age* and *HiEdu*.

Table 1.3 Descriptive Statistics: Large and Small Firms

	Large Firms			Small Firms		
Variables	Before MNP	After MNP	Difference	Before MNP	After MNP	Difference
Market Share	0.449 (0.005)	0.418 (0.004)	-0.031*** (0.007)	0.182 (0.003)	0.188 (0.003)	0.006* (0.004)
Price ($)	19.446 (0.461)	37.203 (0.454)	17.757*** (0.655)	19.673 (0.431)	6.9223 (0.404)	17.250** (0.594)
Price % Change	-0.008 (0.095)	-0.005 (0.067)	0.004 (0.005)	-0.006 (0.164)	-0.010 (0.075)	-0.003 (0.004)
Contract Subs%	0.450 (0.026)	0.515 (0.010)	0.066*** (0.023)	0.569 (0.016)	0.532 (0.007)	-0.037** (0.015)
Data Rev%	0.141 (0.004)	0.171 (0.003)	0.030*** (0.005)	0.145 (0.004)	0.166 (0.002)	0.021*** (0.004)

Standard errors are in parentheses.
*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.

Table 1.4 Market Share as Dependent Variable

	Large Firms	Small Firms
MNP	-0.051**	0.052***
	(0.022)	(0.019)
Lagged HHI	-0.599*	0.034*
	(0.303)	(0.021)
MNP*Lagged HHI	0.388*	-0.092*
	(0.194)	(0.054)
Growth Rate	-0.077**	0.014
	(0.032)	(0.023)
MNP*Growth Rate	-0.056*	-0.047
	(0.034)	(0.033)
Contract Subs%	0.213**	-0.049
	(0.084)	(0.046)
MNP* Contract Subs%	0.019*	0.004
	(0.035)	(0.012)
Marginal Effect of MNP	-0.047*	0.050**
	(0.027)	(0.023)
Observations	1192	2016
Over-identification Test	Chi2(283)=14.76	Chi2(284)=76.99
	Prob>Chi2=1.0	Prob>Chi2=1.0

Dependent variables in all regressions are market share. Estimations are based on GMM.
*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
Standard errors are in parentheses.
All regressions include quarterly dummy, seasonality, country-specific time trends, country fixed effects, firm fixed effects and a constant term. These coefficients are not reported here.
Other coefficients not reported: *Market Share*, (*MNP*Market Share*), *Gov Effectiveness*, *Regulatory Quality*, *GDP per capita*, *Population Density*, *Cellular*/*Fixed/Internet Penetration*, *Teen*, *Young*, *Mid-age* and *HiEdu*.

Table 1.5 Price % Change

	Overall	Large Firms	Small Firms
MNP	-0.539*	-0.140	-0.428**
	(0.312)	(0.143)	(0.208)
Contract Subs%	0.430***	0.446***	0.386**
	(0.121)	(0.149)	(0.149)
MNP*Contract Subs%	0.150***	0.686*	0.019
	(0.050)	(0.365)	(0.330)
Lagged HHI	-1.430	0.197	-0.707**
	(1.199)	(0.391)	(0.342)
MNP* Lagged HHI	1.212*	0.309*	-0.981**
	(0.739)	(0.183)	(0.417)
Growth Rate	0.688*	0.235*	-0.421*
	(0.356)	(0.133)	(0.253)
MNP*Growth Rate	-0.848***	-0.600**	-0.779**
	(0.264)	(0.258)	(0.377)
Marginal Effect of MNP		0.006*	-0.035*
		(0.601)	(0.019)
Observations	3344	1241	2103
Over-identification Test	Chi2(304)=0.00	Chi2(412)=3.38	Chi2(362)=46.26
	Prob>Chi2=1.0	Prob>Chi2=1.0	Prob>Chi2=1.0

Dependent variables in all regressions are *Price % Change*. Estimations are based on GMM.
*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions include quarterly dummy, seasonality, country-specific time trends, country fixed effects, firm fixed effects and a constant term. These coefficients are not reported here.
Other coefficients not reported: Lagged *Price % Change*, *Market Share*, (*MNP*Market Share*), *Gov Effectiveness*, *Regulatory Quality*, *GDP per capita*, *Population Density*, *Cellular*/*Fixed/Internet Penetration*, *Teen*, *Young*, *Mid-age* and *HiEdu*.

Table 1.6 Customer Base Analyses

Dependent Variable	(1) Contract Subs%		(2) Data Rev%	
	Large Firms	Small Firms	Large Firms	Small Firms
MNP	0.069***	-0.017*	0.020**	0.004
	(0.025)	(0.010)	(0.009)	(0.020)
Observations	1238	2363	997	1529
Over-identification Test	Chi2(50)=25.63 Prob>Chi2=0.998	Chi2(50)=19.70 Prob>Chi2=1.000	Chi2(40) = 0.00 Prob>Chi2=1.000	Chi2(40)=6.59 Prob>Chi2=1.000

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions include quarterly dummy, seasonality, country-specific time trends, country fixed effects, firm fixed effects and a constant term. These coefficients are not reported.
Other coefficients not reported: *Gov Effectiveness*, *Regulatory Quality*, *HHI*, *GDP per capita*, *Population Density*, *Cellular*/*Fixed/Internet Penetration*, *Growth Rate*, *Teen*, *Young*, *Mid-age* and *HiEdu*.

References

Aoki, R., J. Small. 1999. The Economics of Number Portability: Switching Costs and Two-part Tariffs. Working Paper, Department of Economics and Center for Research in Network Economics and Communications, University of Auckland, Auckland, New Zealand.

Arellano, M., S. Bond. 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economics Studies*, 58, 277-297.

Beggs, A. 1989. A Note on Switching Costs and Technology Choice. *Journal of Industrial Economics*, 37, 437-440.

Beggs, A., P. Klemperer. 1992. Multi-period Competition with Switching Costs. *Econometrica*. 60, 651-666.

Business Monitor International (BMI). *BMI Global Handset Market: Key Trends & Opportunities*, *2007-2014*, *Special Report*, 2010.

Chen, Y. 1997. Paying Customers to Switch. *Journal of Economics & Management Strategy*, 6, 877-897.

Dubé, J.-P., G. J. Hitsch, P.K. Chintagunta. 2005. Tipping and Concentration in Markets with Indirect Network Effects. *Marketing Science*, 29, 216–249.

Danaher, P. J., M.C. Denise, J. R. McColl-Kennedy. 2008. Who Wants a Relationship Anyway? Conditions when Consumers Expect a Relationship with Their Service Provider. *Journal of Service Research*, 11, 43-62.

Electronic Communications Committee. Implementation of Mobile Number Portability in CEPT Countries, ECC Report 31, 2005.

Farrell, J., P. Klemperer. 2007. Coordination and lock-in: Competition with switching costs and network effects. *Handbook of Industrial Organization*, 3(31) 1967-1005. Elsevier.

Farrell, J., C. Shapiro. 1988. Dynamic Competition with Switching Costs. *RAND Journal of Economics*, 19, 440-449.

Federal Communications Commission (FCC). Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services, *Ninth/ Eleventh/ Thirteenth/ Fourteenth Report*, 2004/2006/2008/2009.

Fudenberg, D., J. Tirole, 2000. Customer Poaching and Brand Switching. *RAND Journal of Economics*, 31, 634-657.

Gans, J. S., S.P. King, G. Woodbridge. 2001. Numbers to the People: Regulation, Ownership and Local Number Portability. *Information Economics and Policy*, 13, 167-180.

Gehrig, T., R. Stenbacka. 2004. Differentiation-induced Switching Costs and Poaching. *Journal of Economics & Management Strategy*, 13, 635-655.

International Telecommunication Union (ITU), Trends in Telecommunication Reform 2012: Smart Regulation for a Broadband World, 2012.

International Telecommunication Union (ITU). ICT Statistics Newslog. CCK confirms 1April launch of MNP after six years of delay, 2011.

Klemperer, P. 1987a. The Competitiveness of Markets with Switching costs. *RAND Journal of Economics*, 18, 138-150.

Klemperer, P. 1987b. Entry Deterrence in Markets with Consumer Switching Costs. *Economic Journal (Supplement)*, 97, 99–117.

Lee, J., Y. Kim, J. Lee, Y. Park. 2006. Estimating the Extent of Potential Competition in the Korean Mobile Telecommunications Market: Switching Costs and Number Portability. *International Journal of Industrial Organization*, 24, 107–124.

Niculescu, M. F., S. Whang. 2011. Codiffusion of Wireless Voice and Data Services: An Empirical Analysis of the Japanese Mobile Telecommunications Market. *Information Systems Research*, 23, 260-279.

OECD. *OECD Communications Outlook 2009*. OECD Publishing, 2009.

Shapiro, C., H.R. Varian. 1999. *Information Rules: A Strategic Guide to the Network Economy*. Harvard Business School Press, Boston, MA.

Shi, M., J. Chiang, B. Rhee. 1996. Price Competition with Reduced Consumer Switching Costs: The Case of 'Wireless Number Portability' in the Cellular Phone Industry. *Management Science*, 52, 27-38.

Shin, J., K. Sudhir. 2009. Switching Costs and Market Competitiveness: Deconstructing the Relationship. *Journal of Marketing Research*, 46, 446-449.

Taylor, C.R. 2003. Supplier Surfing: Competition and Consumer Behavior in Subscription Markets. *RAND Journal of Economics*, 34, 223-246.

Viard, B. 2007. Do Switching Costs Make Markets More or Less Competitive? The Case of 800-Number Portability. *RAND Journal of Economics*, 38, 146-163.

Villas-Boas, J. M., 1999. Dynamic Competition with Customer Recognition. *RAND Journal of Economics*, 30, 604-631.

Woodridge, J. 2002. *Econometric Analysis of Cross-Section and Panel Data*. MIT Press, Cambridge, MA.

This chapter, in full, is co-authored with Kevin Zhu. The dissertation author was the primary author.

Chapter 2

Does Customer Poaching Payoff in the Face of Competition and Technology Change? Evidence from the Global Wireless Industry

Abstract

Is investment in acquiring new customers a source of competitive advantage, or simply the cost of competing? How would new technologies moderate this relationship? This paper studies the effectiveness of customer poaching in the face of growing acquisition cost coupled with decreasing retention rate. Specifically, we investigate how spending on customer acquisition affects business performance along three stages of customer relationship management: acquisition, retention, and revenue generation. We focus on the role of competition in both acquisition spending and technology in these relationships. We evaluate these issues in the wireless telecomm industry using a firm-level panel dataset of 38 operators in seven countries over eight years (1997-2005). We find that acquisition spending helps to attract new customers. However, it does not improve customer retention or revenue. Rivals' competitive actions substantially reduce

the effectiveness of the focal firm’s acquisition effort. Using new technology alleviates this adverse effect, which suggests the strategic role of technology in competing for customers. Our results suggest that customer acquisition efforts do not necessarily carry on to firm performance, especially in the presence of intensified competition. It becomes important that firms synchronize their marketing strategies and technology strategies to improve performance and achieve competitive advantage in technology-intensive and customer-centric markets.

2.1 Introduction

Wireless telecommunication service is one of the fastest growing industries in the global economy. It has been characterized by intensified market competition. Customer relationship management (CRM) is paramount in this competition. Firms (wireless operators) often poach customers from rivals, usually with handset subsidies, cash rebates, and other financial incentives. These efforts reduce consumer switching costs, and induce customers to switch. With substantial spending on customer acquisition in the past decade (Figure 1, EMC 1997-2005), firms are faced with an important question: Do these acquisition efforts pay off as competition intensifies?

To assess this question, first we need to evaluate how many new customers are acquired successfully, i.e., customer acquisition. Further, the intense competition for customers also leads to more frequent switching in this industry than in others (Neslin et al. 2006). Hence, customer retention is another leading concern for firms. Retention is measured by churn rate (inversely), the percentage of customers leaving in a given period. For instance, the average monthly churn rate was 3% in the U.S. in 2005 (FCC 2006). This means that a firm lost about 36% of its customers each year. Replacing lost customers to maintain the subscriber base is costly, especially in a saturated market. It is estimated that customer churn wipes out 20% of the industry revenue by billions of dollars a year (FCC 2005).

The increasing expenditure on customer acquisition, coupled with significant churn, raises another question: Does acquisition spending increase customer retention? The literature has documented the effect of acquisition spending on customer decisions (e.g., Hausman 2002). Yet, most of these studies are performed at the individual customer level (e.g., Thomas 2001; Reinartz et al. 2005), whereas it is less clear whether acquisition spending will lead to better firm performance (Aksoy et al., 2008). Following customer acquisition and retention, we also want to see if there is evidence to show newly acquired customers indeed help to grow revenues for firms..

The above questions become even more interesting when we consider competitors: what if rivals also adopt a similar strategy? As more firms respond aggressively to each other, does a firm's acquisition effort transform from being a success driver to being a failure preventer? Successful implementation of customer strategy depends on whether firms can incorporate rivals' actions into decision-making (Boulding et al. 2005). The literature is extensive on customer acquisition and retention (e.g., Reinartz et al. 2005); however, it remains silent on the role of competition in CRM (Boulding et al., 2005). To enhance our understanding of whether customer poaching can lead to competitive advantage, we need to integrate market competition into the analysis of customer acquisition.

The effectiveness of customer poaching can also be affected by firms' technology strategy, because marketing and innovation are two *complementary* "basic functions" crucial to firm performance (Drucker 1973; Ramaswami et al. 2009). This is indeed the case in our research context. Wireless service is enabled by communication technologies.

For example, GSM and CDMA are 2G standards; WCDMA and CDMA2000 are 3G standards.[21] Technology advances rapidly in this industry, and is a key to service quality, brand differentiation, and user experience. This in turn may affect whether customer acquisition is effective; using newer technology may give firms a competitive edge in the poaching game.

Besides market competition, industry environment also affects the effectiveness of customer strategy (Jansen et al. 2006). Market penetration is one of such contextual factors (e.g, Song et al. 2005). When market becomes saturated, aggressive competition for customers is likely to result in firms eating each other's share. By exploring the moderating effect of market penetration, we hope to provide insights into how firms should adjust their strategy at different stages of industry maturity.

To sum up, this paper examines the return of customer acquisition on business performance. Specifically, we study the following research questions: (1) How does customer acquisition spending affect acquisition rate, retention rate and revenue? (2) What is the role of rivals' competitive actions (in acquisition spending and technology) in these relationships? (3) How does market penetration moderate these relationships?

We develop these research questions into six hypotheses. We then analyze a firm-level panel dataset of 38 operators in seven countries over eight years (1997-2005). Our findings show that customer acquisition spending helps acquire new customers, but does not necessarily improve customer retention or average revenue. Rivals' acquisition

[21] GSM refers to Global System for Mobile Communications, CDMA is Code Division Multiple Access, WCDMA is Wideband CDMA.

spending has a negative impact on these relationships. What appears to matter is the acquisition spending *relative to rivals'*, i.e., the level of differentiation in acquisition efforts as opposed to the absolute level of spending. The relationship between acquisition spending and customer retention suggests that acquisition cost may not pay off in the presence of competition. Further, technology shows an important moderating effect; firms ambidextrous in both customer and technology strategies have an edge over competitors.

The rest of the paper is organized as follows. We first provide a theoretical background, and propose hypotheses for our research questions. This is followed by data description, empirical analysis and discussion of results. We conclude with key findings, contributions and extensions.

2.2 Literature Review and Hypotheses

In this section, we briefly review the literature on different aspects of the customer-firm relationship (e.g., Gupta and Zeithaml 2006). This includes customer acquisition, customer retention, market competition (in customer acquisition and technology), industry characteristics, and their relationships with firm performance.

2.2.1 Customer Acquisition

A firm's customer strategy is its "ability to identify attractive customers and prospects, initiate and maintain relationships with these attractive customers, and leverage these relationships into customer-level profits" (Morgan 2012). Customer acquisition is among the first in this process.

Firms acquire customers through various tactics, such as introductory pricing and promotions. In markets with consumer switching costs, this kind of enticing actions is called "paying customer to switch" (Chen 1997), or "customer poaching" (Fudenburg and Tirole 2000). The switching cost literature suggests that coupons and discounts can induce customer to switch and increase revenue/profit (e.g., Caminal and Matutes 1990). Indeed, low cost of handsets is a determinant of purchase decision for wireless service (Hausman 2002). The marketing literature also documents that introductory offers can boost demand and increase sales (Dekimpe and Hanssens 1999). This is because advertising can increase product differentiation, brand awareness and customer loyalty (Boulding et al. 1994, Chandy and Tellis 2000). Hence, it is expected that greater acquisition efforts help to obtain new customers.

Once acquired, are customers going to stay with the firm? This is the central question in the next stage, i.e., customer retention. Customer acquisition and customer retention are interrelated (Thomas 2001). Acquisition can improve retention through customer satisfaction (Blattberg et al. 2001; Bolton et al. 2004). If a firm successfully creates value for its customers through acquisition efforts, it would affect customer purchase behavior in a way favorable for the firm. This can increase sales volume, and customer satisfaction and loyalty, which in turn may better retain customers (Gustafsson et al. 2005; Zineldin 2006).

Customer retention is a driver of customer value and revenue growth (Grant and Schlesinger, 1995). Acquiring new customers tend to be more costly than keeping existing customers (Reichheld and Sasser, 1990; Reichheld 1996). Further, existing customers can generate greater value. For instance, 1% improvement in customer retention raises firm value by 5%, while 1% increase in acquisition cost only improves it by 0.1% (Gupta et al. 2004). Meanwhile, the evidence is mixed. For instance, retention effort may incur future obligations to customers (i.e., liabilities), rather than increasing future revenues from customers (i.e., assets) (Shugan 2005). We believe that if acquisition is effective to increase customer retention, and in turn customer retention improves revenue, then there should be a "chain reaction". That is, customer acquisition efforts ultimately contribute to higher revenue, and enhance the firm's competitive advantage. Together, we propose the following:

Hypothesis 1 (H1). Higher acquisition spending is associated with higher acquisition rate, higher retention rate (lower churn), and greater revenue.

Customers differ in switching cost, and may have different tendency of being acquired. Identifying the right kind of customer segments to acquire can help allocate acquisition effort more effectively. In the wireless industry, there are two segments of customers. The first is contract customers, who sign service contract for one or two years. They are subject to early termination fee, and thus incur high switching costs. The other is prepaid customers without contract obligation. Is acquisition spending more attractive to contract or prepaid customers? We conjecture that prepaid customers, who incur low switching costs, are more sensitive to acquisition spending. Hence, we propose the following:

Hypothesis 2 (H2). Higher spending in customer acquisition is associated with higher acquisition rate of prepaid customers than that of contract customers.

2.2.2 Market Competition

The effectiveness of firms' strategy depends on the competitive environment (Hambrick 1983, Zahra and Bogner 1999). For instance, market competitiveness moderates the relationship between firms' market orientation strategy and performance (Slater and Narver 1994). The degree of competition can be measured by the number of competitors, and the number of areas in which firms compete (Miller 1987, Jansen et al. 2006). "Competitor hostility" in the literature suggests that the breadth and aggressiveness of competitors' actions can be measured in various dimensions, including pricing and technology (e.g., Miller 1987; Adner 2002). Consistent with this notion, we discuss the moderating effects of competition in two dimensions: competition in customer acquisition and competition in technology.

2.2.2.1 Competition in Customer Acquisition

The literature suggests that if rivals imitate a firm's strategy, this will weaken the firm's competitive advantage (Barney 1991; Conner 1991); if a strategic relationship is general, then the advantage may be competed away. Specific to our research context, acquisition spending can attract new customers and improve firm performance.

Meanwhile, as competition intensifies, it is unclear whether the acquisition effort still pays off. Competition can generate an escalation effect: firms increase expenditure to compete for customers, even when rivals do the same. However, there is little evidence about whether the expenditure can achieve the expected results (Boulding et al. 2005). Acquisition can generate a "spoiling effect" on retention (Dong et al. 2011). That is, if only new customers receive price discounts as a result of acquisition effort, then existing customer may feel that they are not treated fairly and tend to be lured away by competitors. Along this line, we hypothesize the following:

Hypothesis 3 (H3). The positive relationship between customer acquisition spending and business performance (acquisition rate, retention and revenue) is negatively moderated by rivals' acquisition spending.

2.2.2.2 Competition in Technology

New technology enables service innovation, which enhances a firm's capability to create new value for customers (Itami and Numagami 1992; Morgan 2012). This is particularly relevant in the wireless industry. For example, 3G technology (WCDMA and CDMA2000) is a major breakthrough; it delivers faster data transmission than 2G. Hence, we expect that technology plays an important role in the return on customer acquisition, and the pattern of return may vary across technology generations (2G vs. 3G).

Whereas marketing strategy communicates customer value, technology innovation creates value, and is regarded as one of the core value-creating capabilities that drive firm performance (Slater and Narver 1994). They are complementary, and generate a positive interaction effect on firm performance. According to the contingency theory, “for each strategic orientation there exists a configuration of organizational characteristics that fits the strategy to yield superior performance” (Slater et al. 2006. p.1221). Therefore, technology innovation should fit into customer strategies (e.g., customer acquisition). We expect that the influence of customer acquisition spending on firm performance would depend on a firm’s ability to align technology adoption with acquisition efforts. If the firm lags behind rivals in terms of technology in competition, then the customer strategy is less effective. Together, we propose the following:

Hypothesis 4 (H4). *The positive relationship between acquisition spending and business performance (acquisition rate, retention and revenue) is strengthened by the focal firms’ technology leadership, and weakened by its rivals’ technology leadership.*

Further, customer heterogeneity can affect the above relationship. High-value contract customers may be more responsive to new technology with greater willingness to pay than prepaid customers. If a firm has more customers on contracts, integrating new technology into customer acquisition spending would be more effective to improve business performance. This leads to the hypothesis about customer base composition:

Hypothesis 5 (H5). For firms with a higher percentage of contract customers, the positive relationship of acquisition spending-technology-performance is stronger.

2.2.3 Industry Characteristics

Market penetration is an important characteristic affecting competition. If a market is saturated and all customers incur switching costs, the competition for customers may likely result in a zero-sum game. This can be illustrated by the simplest switching cost models with price discrimination. For example, in a two-period duopoly, the equilibrium market share of both firms is not a function of price discounts (e.g., Chen 1997). This implies that acquisition effort through lower prices is ineffective. In contrast, if there are many customers new to the market, then the average switching costs on the market are low. Consequently, the acquisition spending will be more effective, because attracting unsubscribed customers is easier than poaching rivals' customers. Hence, we propose the following:

***Hypothesis 6* (H6).** The positive relationship between acquisition spending and business performance is negatively moderated by market penetration.

2.3 Data and Variables

To test our hypotheses, we compile a firm-level quarterly dataset of 38 major wireless operators in seven countries over eight years (1997–2005) from various sources (e.g., the EMC World Cellular Database). The unit of analysis is operating company. Since data are not equally available for each company, the panel is unbalanced.

The variable of major interest is *Acquisition Costs* (*AC*). It is defined as a firm's average costs spent to acquire a new customer, i.e., cost per gross addition. It is calculated by dividing the total acquisition spending by the number of newly acquired customers in period *t*.[22] *AC* typically includes handset subsidies, marketing, advertising, waiver of activation fees and SIM cards. Other variables include *Subscribers* (total number of customers of a firm), *Contract%* (percentage of customers on contract), *Churn* (percentage of customers leaving the network), and average revenue per user (*ARPU*).

We further construct the following variables. *Acquisition Rate* is the percentage of newly acquired customers relative to the average number of *Subscribers* in periods *t* and *t*-1. We also calculate this variable for the contract and prepaid customer segments respectively, i.e., *Contract Acquisition Rate*, and *Prepaid Acquisition Rate.* To capture competition, we define *RivalAC* as the average acquisition costs of the focal firm's rivals in the same country at time *t*.

Our dataset also provides information about technological standards that a firm uses. We differentiate six major standards, and separate them by technology generations, i.e., 2G (GSM, CDMA, TDMA[23]) and 3G (WCDMA, and CDMA2000).[24] We construct a binary indicator *3G*, which equals one if a firm uses 3G technology, and zero otherwise. *Rival3G_n* represents the number of rivals using 3G, and *Rival3G* is a binary indicator of whether any rivals using 3G.

We further supplement this firm-level dataset by country-level variables from the Global Market Information Database. This includes *Cellular Penetration* (the number of cellular subscribers per 100 inhabitants), *Fixedline Penetration* (the number of fixedline

[22] This operation is consistent with the literature, e.g., Gupta et al. 2004.
[23] TDMA refers to Time Division Multiple Access.
[24] During our sample period, 2G and 3G were the dominant technology generations. The analogue standards (1G) had been phased out, and the latest 4G was not emerging yet.

phones per 100 inhabitants), *GDP per Capita*, and national demographics (the percentage of age groups 13-19 (*Teen*), 20-29 (*Young*), and the percentage of people with high education (*HiEdu*) out of the total population). We also compile market share information from a series of OECD Communications Outlook (1997-2007). We calculate the Herfindahl-Hirschman Index (*HHI*), sum of squares of all firms' market share in a country.

Table 1 presents the descriptive statistics. The average *Acquisition Costs* is \$269.09, which is about the price of handset subsidies for a new customer. The monthly average *Churn* is 2.26%, meaning on average a firm loses about 27% of customers a year. The *ARPU* is \$42.94, about the monthly payment of a customer.

2.4 Empirical Analysis

2.4.1 Model Specification

We use the following empirical models to test our hypotheses. The dependent variable *PF* represents performance measures (i.e., customer acquisition rate, retention rate, and average revenue per user). As a baseline, we include in Model (1) only the focal firm's own acquisition cost, without considering any competition effects yet:

$$PF_{ijt} = \alpha + \beta_1 AC_{ij,t-1} + \gamma Z_{jt} + \delta_i + \lambda_j + u_t + \varepsilon_{ijt}, \qquad 1)$$

where $AC_{ij,t-1}$ is the acquisition cost of firm *i* in country *j* at time $t-1$; Z_{jt} controls country-level variables; u_t includes quarterly dummy, seasonality and country-specific time trends; δ_i and λ_j are firm and country fixed effects; ε_{ijt} is the error term not captured by the regressors.

In an augmented Model (2), we introduce market competition by including rivals' *AC* and its interaction with the focal firm's *AC*. This helps to identify how rivals' actions moderate the relationship between acquisition cost and acquisition rate. In addition, to examine the role of technology, we also include variables representing firms' technology status (*3G* and *Rival3G_n*), and their interactions with *AC*. This model specification investigates more comprehensively how customer and technology strategies interact in a competitive environment.

$$\begin{aligned} PF_{ijt} = \alpha &+ \beta_1 AC_{ij,t-1} + \beta_2 RivalAC_{(-i)j,t-1} + \beta_3 RivalAC_{(-i)j,t-1} * AC_{ij,t-1} \\ &+ \beta_4 3G_{ij,t-1} + \beta_5 Rival3G\_n_{(-i)j,t-1} + \beta_6 Rival3G\_n_{(-i)j,t-1} * AC_{ij,t-1} \\ &+ \beta_7 RivalAC_{(-i)j,t-1} * AC_{ij,t-1} * 3G_{ij,t-1} + \beta_8 Rival3G\_n_{(-i)j,t-1} * AC_{ik,t-1} * \\ &+ \gamma Z_{jt}\gamma + \delta_i + \lambda_j + u_t + \varepsilon_{ijt}, \end{aligned} \quad 2)$$

Here $3G_{ij,t-1}$ is a the 3G technology indicator of firm i in country j at time $t-1$; $RivalAC_{(-i)j,t-1}$ and $Rival3G\_n_{(-i)j,t-1}$ are the average acquisition cost of firm *i*'s rivals, and the number of rivals using 3G at $t-1$,[25] respectively; other variables are defined as before.

Firms with higher acquisition rate may be able to spend less but manage to acquire customers more efficiently. To account for this possible endogeneity, we make use of the panel structure of the data and apply an instrumental variable (IV) approach. We instrument *Acquisition Costs* by its counterpart in other countries (Hausman 1997),

[25] For robustness, we also use the dummy variable *Rival3G*, and the results are consistent.

conditional on the same technological standards. For instance, the acquisition costs of a CDMA operator in the U.S. at time *t* is instrumented by the average acquisition costs of all CDMA operators in other countries at the same time. On the one hand, a particular firm in a country sets acquisition spending level based on its cost structure and national market demand. Country-specific random shocks contributing to acquisition costs are uncorrelated across countries. On the other hand, handset subsidies account for an important part of customer acquisition cost, and the average price of handsets varies by technological standards, which leads to differential customer acquisition costs across standards. [26] Moreover, handsets in most countries are usually provided by a few multinational manufacturers. Conditional on the same standard, these handsets share similar production costs. Therefore, operators with the same standard in different countries are subject to common cost element, which affects their customer acquisition costs. This IV helps remove country-specific effects and still captures the common cost information.

To address the possible endogeneity of 3G technology, we use the number of rivals using 3G in the previous quarter as an IV. The deployment of a new technology by rivals may generate competitive pressure for the focal firm to adopt as well.

For variables involved in the interaction terms, we center them by subtracting the mean from each variable. The mean centering reduces multicollinearity and makes the interpretation of results more meaningful (Aiken and West 1991).

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[26] The average acquisition costs of CDMA ($319) are greater than that of GSM ($196). This is possibly due to higher price of CDMA handsets, due to higher royalty fees and less economies of scale as CDMA is a newer standard relative to GSM.

2.4.2 Results and Discussion

2.4.2.1 Baseline Results

Table 2 presents the results of IV estimation. In the baseline Model (1), the acquisition cost has a significant impact on acquisition rate (Column 1, Table 2). Hence, acquisition spending helps to gain more customers. For customer retention, surprisingly, the coefficient of *Acquisition Cost* is insignificant (Column 3, Table 2). Similarly, it is insignificant for ARPU as well (Column 5, Table 2). Hence, we do not find statistical evidence that acquisition cost helps increase retention or revenue. These unexpected results indicate that acquisition spending may not be effective in reducing churn or increasing revenue. Together, H1 is only partially supported.

The linkage from acquisition rate to retention/revenue seems weak or missing. To probe this deeper and test H2, we turn to customer base analysis. We use *Contract Acquisition Rate* and *Prepaid Acquisition Rate* as two dependent variables, and investigate their relationship with acquisition spending, respectively. The regression results are reported in Table 3. The coefficient of acquisition cost for the prepaid acquisition rate (0.009, at 1% level) is greater than that for the contract acquisition rate (0.007, at 1% level).[27] This supports H2, and seems to suggest that customers with lower switching costs (prepaid) are more sensitive to firms' acquisition efforts. The result may help to explain why we observe that acquisition spending can attract more customers, but does not increase retention rate or revenue. Prepaid customers are easier to lure, probably because they are low-value customers with greater price sensitivity. Meanwhile, they are

[27] We use net increase in contract/prepaid customers as alternative dependent variables, and get similar results.

also easy to lose, because they incur low switching costs without service contract obligations.

2.4.2.2 Moderating Effects of Competition

In the results of Model (2), the signs and magnitudes of *Acquisition Cost* are consistent with the baseline models. We will focus on newly added variables in the discussion below.

As reported in Column 2 of Table 2, the coefficient of rival's acquisition cost is negative on customer acquisition rate (-0.058, at 10% level). As the focal firm's customers are poached away by rivals, its acquisition rate decreases (with a smaller customer base, all else being equal). It implies that the effectiveness of the focal firm's acquisition effort is dampened by competition.

The coefficient on *RivalAC*AC* is positive (at 10% level). It suggests that when rivals are more aggressive in acquisition spending, an increase in one's own acquisition spending can improve customer acquisition rate. This shows that firms are engaging in a race to attract customers.

The effect is stronger for firms with 3G, as can be seen from the significantly positive coefficient on the three-way interaction *RivalAC*AC*3G*. Customer acquisition spending seems to be the cost of competition; firms may be at competitive disadvantage if falling behind the race. However, 3G can be effective in counter balancing the rivals. This is because technology can be an important factor in customer subscription decisions.

Firms offering services enabled by new technology (e.g., data service of 3G) may be more attractive to customers. Hence, new technology can complement customer acquisition effort, and help firms gain competitive edge in the competition for customers. This result supports H3, and underscores the importance to integrate new technology into customer strategy.

The coefficient of $Rival3G\_n$ is negative and highly significant (at 1% level), showing that competition with new technology can significantly damage the focal firm's acquisition rate.

Fortunately, this adverse effect can be mitigated if the focal firm also competes with the new technology (the positive coefficient on *RivalAC*AC*3G*). The three-way interaction $Rival3G\_n * AC * 3G$ also has a positive coefficient. When more rivals use new technology, the focal firm also needs to have new technology to make acquisition spending effective. This again demonstrates the complementarity of customer and technology strategy, and provides further evidence for H3.

We also examine the moderating effects of competition on the acquisition rate of contract vs. prepaid customers separately. Consistent with the baseline models, the coefficients of *AC* are significantly positive (Columns 2 and 4, Table 3). In addition, the magnitude is greater for the acquisition rate of prepaid than that of contract customers. This again supports H2. The interaction terms demonstrate similar patterns as in the overall acquisition rate analysis. The coefficient of $RivalAC * AC$ is greater for prepaid acquisition rate than for the contract acquisition rate. This suggests that prepaid customers are more sensitive to acquisition enticement. In the presence of rivals' competition, increasing the focal firm's acquisition spending can lead to greater acquisition rate in the prepaid segment than in the contract segment. Meanwhile, this effect is evident for contract customers only if the firm uses new technology (coefficient of the three-way interaction *RivalAC*AC*3G* is positively significant for contract customers). This indicates that contract customers may be more responsive to new technology. The focal firm can leverage 3G to retain contract customers when facing rivals' acquisition efforts. To make customer acquisition strategy effective, it is important to make use of new technology to attract these high-value customers, ahead of the competition or at least not falling behind.

To obtain a deeper understanding of how competition in acquisition spending affect acquisition rate in different customer segments, we stratify the sample into two subsamples: high/low acquisition spending. The sample split is based on the level of *relative* acquisition spending, i.e., whether the focal firm's acquisition spending is higher or lower than the average of its rivals'. Figure 2 graphs fitted values from the regressions for sub-samples. First, the acquisition rate has a much higher elasticity with respect to acquisition cost in the prepaid segment than in the contract segment. This further confirms H2. Again, this result also explains why acquisition spending is insignificant in the baseline analysis of retention and revenue: low-value prepaid customers incur low switching costs and can churn easily. Second, when the relative acquisition cost is low ($AC < RivalAC$), the prepaid acquisition rate is more elastic than the case with a high relative acquisition cost ($AC > RivalAC$): the prepaid fitted line is steeper in the top graph.

The pattern is the opposite for contract acquisition rate (the contract fitted line is flatter in the top graph). In either case, the elasticity of acquisition spending is lower for contract customers. These results further confirm H2. Differentiation in acquisition cost is important to keep up the race of customer poaching, especially in the low-value customer segment.

Turning to customer retention, we see that competitors' AC has a significantly effect on churn (Column 3, Table 2). The greater acquisition effort of its rivals, the harder it is for the focal firm to retain customers. This might help explain the insignificant effect of the focal firm's acquisition spending on retention. Another possible interpretation is the "spoiling effect" of customer acquisition (Dong et al. 2011). Existing customers may feel that they are not treated fairly if sales promotions are given only to new customers. They tend to be lured away by rivals and jump ships. Hence, more acquisition efforts may not help retain customers and even increase churn rate. This suggests that customer acquisition and retention are different aspects of customer strategy, and they require different kinds of efforts. The three-way interactions *RivalAC*AC*3G* again are significant. This means that 3G, especially in combination with AC, is effective to reduce churn, thus counter-balancing rival's AC. The effect of acquisition spending, combined with new technology, is important to retain customers. Although customer acquisition spending does not effectively translate into customer retention, technology can be a way to remedy this effect. This is because better services enabled by new technology can enhance the attractiveness of the focal firm, making customers less likely to switch away. This again supports H3 and H4.

The coefficient of $Rival3G\_n$ on churn is positive. When rivals have advantage in new technology, the focal firm's customers tend to be lured away (thus higher churn). Fortunately, this adverse effect can be mitigated by the focal firm's use of 3G in combination of acquisition efforts (the negative coefficient on $Rival3G\_n * AC * 3G$). The complementarity of customer and technology strategy reduces churn, providing another evidence for H4.

For the results on ARPU, the standalone effect of acquisition spending is again insignificant. Perhaps this is neutralized by rivals' acquisition spending (negative coefficient of *RivalAC*, last column of Table 2). There is a difference here. *RivalAC*AC* is positive for acquisition rate, but negative for ARPU. This means that, while *AC* can counter-balance *RivalAC* to win back customers in terms of acquisition rate, but increasing AC will hurt the firm's revenue.

Rival's use of new technology really hurts the focal firm's revenue (*Rival-3G-n* is highly negative). This shows the danger of falling behind on the technology curve in technology-intensive markets. Fortunately (in a limited sense), the firm can mitigate this risk by combining new technology and acquisition efforts (significant coefficients of the two three-way interaction terms *RivalAC*AC*3G* and $Rival3G\_n * AC * 3G$). This result highlights that technology-strategy integration is important to revenue performance, consistent with the findings in acquisition rate and churn analysis.

We graph the moderating effect of rivals' acquisition spending on the focal firm's ARPU in Figure 3, in order to demonstrate the role of competition in acquisition spending and different technologies. We define high/low levels of rivals' acquisition spending as one standard deviation above/below the mean. The graphs show that when rivals' acquisition spending is high, increasing one's own acquisition effort will increase ARPU when the firm uses 3G. Interestingly, 2G exhibits opposite behavior. This seems to imply that new technology tends to strengthen the return of acquisition spending.

With broadband capability, 3G enables faster data transmission and greater variety of value-added data services with better quality, and create demand (such as Internet, GPS, and mobile TV) that were not available in 2G. This on the one hand may drive down acquisition costs for customers keen for the latest technology. On the other hand, it could generate greater ARPU by charging a higher price to extract more consumer surplus. The overall effect is that 3G has greater return on acquisition. This is the major difference we observe as the industry migrates to 3G.

As an additional illustration, we do a sample split analysis based on the relative acquisition spending across technology generations.[28] We define a firm as low/high acquisition spending if its acquisition cost is lower/higher than that of the rivals'. The fitted values of ARPU are plotted in Figure 4. It shows that 3G technology enhances the effectiveness of acquisition cost on ARPU; this pattern is more evident when a firm's acquisition spending exceeds its rivals (3G fitted line is steeper than that of 2G in the bottom graph). This again supports H4.

[28] We also calculate the difference in acquisition cost between the focal firm and its rivals, and use it as an alternative explanatory variable. The results are similar.

Next, we examine H5 and analyze how the complementarity of acquisition spending and technology would generate different effects according to firms' customer base composition. We separate firms into *H*/*L* sub-samples if their contract customer percentage is above/below the median. The results are reported in Table 4, and we mainly focus on the three-way interactions. The coefficients of *RivalAC*AC*3G* and *Rival3G_n*AC*3G* are positive for customer acquisition rate in *H* firms, while insignificant for *L* firms. New technology may be more valuable to contract customers. Firms with more contract customers tend to have higher acquisition rate if they deploy new technology. Similar patterns are found for churn and ARPU. Hence, H5 is supported. *H* firms have a high percentage of contract customers, who tend to be more sensitive to the availability of new technology. To better contain churn and improve revenue, firms should account for its customer base composition when integrating new technology into customer acquisition spending. For firms with more customers on contract, it is wise to introduce new technology early.

In sum, our results provide support for H3, H4 and H5. We show that customer acquisition cost does increases acquisition rate, which may justify the spending of acquisition cost. Meanwhile, this effect is substantially moderated by rivals' acquisition effort and their use of advanced technology. New technology is important to improve the effectiveness of acquisition efforts on not only acquisition rate, but also retention and revenue. Our results imply that customer acquisition spending may be a cost of competing. It is a source of competitive advantage only when new technology is also incorporated. If all firms in a market use the same strategy (e.g., spend aggressively to acquire customers), the relative advantage is likely to diminish. In this case, firms that strategically differentiate themselves by leading in new technology will sustain competitive advantage. Further, the significance of new technology to customer strategy depends on firm's customer base composition. For firms with more contract customers, the complementary strategy is more effective to achieve better performance.

2.4.2.3 Market Penetration

Lastly, we interpret the role of market penetration for different performance measures. As can be seen from the last two rows of coefficients in Table 2, higher penetration is associated with lower acquisition rate and lower ARPU, but insignificant in churn rate. As a market gets saturated, it becomes harder to acquire new customers. The only source is to poach rivals' customers. Yet, customers in mature markets may have settled in with their preferred service providers; they are less likely to be poached easily, especially for contract customers. Overall, such markets behave like stable equilibrium. Aggressive acquisition spending can in fact aggravate churn and reduce ARPU in such markets (coefficients of *Penetration*AC* in the last row). The adverse moderating role of market penetration suggests that firms should take into account the stage of market development when designing customer strategy. Hence, H6 is supported.

Moreover, the moderating effect of market penetration differs across customer segments (Table 3). While the coefficient on *Penetration*AC* is negative for contract acquisition rate, it turns to be positive for prepaid acquisition rate. With high penetration rate, acquisition spending is effective only to acquire prepaid customers. Customers who have not entered the market are those with low willingness to pay, i.e., prepaid customers. Industry evidence suggests that prepaid segment becomes an important source of market growth as the industry gets more mature (GSM Association, 2011). Our finding is consistent with this observation.

2.5 Concluding Remarks

Does customer poaching pay off if rivals take the same action? How does the adoption of new technologies change the equation? These are significant issues in CRM. With rapid technology advancement and fierce market competition, firms must cope with both customer behavior (switching) and technological forces (wireless technology change) to sustain performance.

In this study, we focus on the role of competition in this acquisition-performance relationship, specifically competition between firms in acquisition spending and service technology. We find that firms with ambidexterity in both customer strategy and new technology can sustain better performance and gain a competitive advantage.

Our study has the following features. First, it identifies the complementariy between customer strategy and new technology, and highlights its importance to business performance in the presence of competition. The next generation technology, which delivers better service and creates greater value for customers, can better leverage the effectiveness of acquisition spending. Hence, customer poaching is not a standalone strategy, and should be aligned with technology adoption. Our findings reveal how ambidextrous firms coordinate customer poaching and technology innovation, and successfully respond to competition. This enhances the understanding of integrating customer and technology initiatives in the marketing literature.

Second, we underscore *customer heterogeneity* as a key to business performance; the complementariy between customer strategy and new technology depends on customer base composition. Whereas acquisition spending helps acquire new customers, it does not necessarily retain customers as rivals respond aggressively. Instead, it creates a peculiar condition to churn customers among firms, and does not improve revenue. Contract customers, the high-value segment incurring high switching costs and more sensitive to new technology, can help better contain churn and grow revenue. To better allocate acquisition resource and enhance its effectiveness, it is critical to identify customer segments that are more valuable. Also, it is crucial to account for customer base composition when designing marketing strategy. Complementing acquisition efforts with new technology is more effective for firms with more high-value customers.

Third, our global data provides an opportunity to identify market penetration as an important contextual factor. When a market saturates, acquiring customers means that firms poaching and exchanging customers from each other. In this case, the role of technology strategy is more prominent in gaining a competitive edge.

Our findings also provide useful managerial implications. They are likely to be helpful for managers to understand market competition and formulate strategic response to rivalry. First, firms should be careful not to be carried away by the competition for acquiring customers at whatever costs. Devoting resources to customer acquisition can be costly, especially when rivals respond aggressively. Managers should re-evaluate their decision to continue with the race for poaching customers. Second, we suggest to managers that customer acquisition spending is not an isolated decision. Service technology, customer heterogeneity and market penetration play important roles in the relationship between acquisition spending and business performance. Before engaging in heavy spending to acquire customers, managers should be aware of the firm's customer base composition, incorporate the technology strategy, and assess the stage of the market development.

This study has limitations that leave open several opportunities for future research. First, the acquisition spending is aggregated averages; we do not have detailed information about specific promotions, discounts or subsidized handsets. Second, to further understand the outcome of poaching strategy, it would be informative if we can examine a more comprehensive list of performance measures, such as customer satisfaction and financial performance (e.g., profit, return on assets). The empirical testing is left for future research when more data are available.

Notwithstanding these limitations, our paper enhances the understanding of customer acquisition strategy in the wireless industry. Competition for customers, customer heterogeneity, and technology innovation are important drivers shaping the dynamics of this industry. With the emerging next generation technology (4G), we hope to extend our analysis with more recent data. Using the wireless industry as an example, our analysis can also be applied to other markets, where switching costs and service technology are prominent, and customer and technology management plays an important role, such as the cable TV and the Internet services.

Table 2.1 Descriptive Statistics

	Mean	Std. Dev.	Min	Max	Obs
Firm-level variables					
Acquisition Costs ($)	269.089	151.777	40.750	815	930
Churn (%)	2.255	0.815	0.630	6.550	951
Acquisition Rate (%)	10.630	13.671	-23.481	172.128	901
Contract Subs%	80.494	5.773	76.254	98.400	951
Subscribers (millions)	6.207	7.518	0.011	51.181	951
Contract Acquisition Rate (%)	73.200	3.581	29.506	144	901
Prepaid Acquisition Rate (%)	125.809	38.992	41.990	200	676
Average Revenue per User ($)	42.937	13.449	16.790	85.970	951
3G	0.217	0.413	0	1	929
RivalAC ($)	272.101	131.335	40.750	722.225	913
Rival3G	0.425	0.495	0	1	929
Rival3G_n	1.414	2.108	0	7	929
Country-level Variables					
Cellular Penetration	57.558	20.231	15.240	111.251	929
Fixedline Penetration	60.479	6.546	42.146	68.220	929
GDP per capita	27344.47	6996.747	10178.860	36272.730	929
HHI	0.290	0.114	0.166	0.968	929
Teen	9.547	0.571	7.736	10.674	929
Young	28.949	1.579	26.349	35.284	929
HighEdu	20.807	3.232	14.457	25.219	929

Table 2.2 Results: Effects of Acquisition Spending on Firm Performance

	Acquisition Rate		Churn		ARPU	
	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
AC	0.024**	0.008*	0.06	0.014	-0.015	0.002
3G		-0.005		-0.004		1.417*
RivalAC		-0.058*		0.013*		-0.029***
RivalAC × AC		0.001*		0.001		-0.003*
RivalAC ×AC× 3G		0.001*		-0.005*		0.007*
Rival_3G_n		-0.016***		0.057*		-0.928***
Rival3G_n × 3G		0.017**		-0.004		0.052
Rival3G_n×AC×3G		0.023*		-0.002**		0.0008*
Penetration		-0.005***		0.010		-0.581***
Penetration × AC		-0.045*		0.004**		-0.018*
Observations		865		743		865
R^2		0.449		0.711		0.929

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions include other country-level controls; firm, country and time fixed effects. These coefficients are not reported.

Table 2.3 Effects of Acquisition Spending: Customer Heterogeneity

	Contract Acquisition Rate		Prepaid Acquisition Rate	
	Model (1)	Model (2)	Model (1)	Model (2)
AC	0.014*	0.007***	0.038**	0.009***
3G		-0.005		0.001
RivalAC		-0.006*		-0.010***
RivalAC × AC		0.003**		0.006***
RivalAC × AC × 3G		0.004*		0.001
Rival_3G_n		-0.040***		-0.037**
Rival3G_n × 3G		0.030*		-0.015
Rival3G_n × AC × 3G		0.015*		-0.026
Penetration		-0.002***		-0.013**
Penetration × AC		-0.025***		-0.002*
Observations		865		641
R^2		0.429		0.592

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions include other country-level controls; firm, country and time fixed effects. These coefficients are not reported.

Table 2.4 Effects of Acquisition Spending: Customer Base Composition

	Acquisition Rate		Churn		ARPU	
	High Contract%	Low Contract%	High Contract%	Low Contract%	High Contract%	Low Contract%
AC	0.004	0.005***	0.067	0.0088	0.008	-0.002
3G	0.06	0.0013	-0.001	-0.044	2.093**	2.169*
RivalAC	-0.074*	0.016	0.023*	0.038***	-0.074***	-0.017*
RivalAC×AC	0.0005*	0.0002***	-0.001**	0.001***	0.013***	0.014
RivalAC×AC×3G	0.0015*	0.0011	0.001*	0.0002	0.015*	-0.005
Rival3G_n	0.004	-0.014***	0.002***	0.002***	-0.470***	-1.227
Rival3G_n × 3G	0.006*	0.010	-0.042	0.001*	0.971*	-0.566
Rival3G_n×AC×3G	0.037***	0.022***	-0.002**	-0.001*	0.002*	-0.001
Penetration	-0.007*	-0.003	-0.002**	0.010	0.198	-0.247***
Penetration × AC	-0.001*	0.002**	-0.003*	0.005*	-0.033*	0.027
Observations	420	445	383	360	420	445
R^2	0.546	0.658	0.807	0.768	0.929	0.908

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions include other country-level controls; firm, country and time fixed effects. These coefficients are not reported.

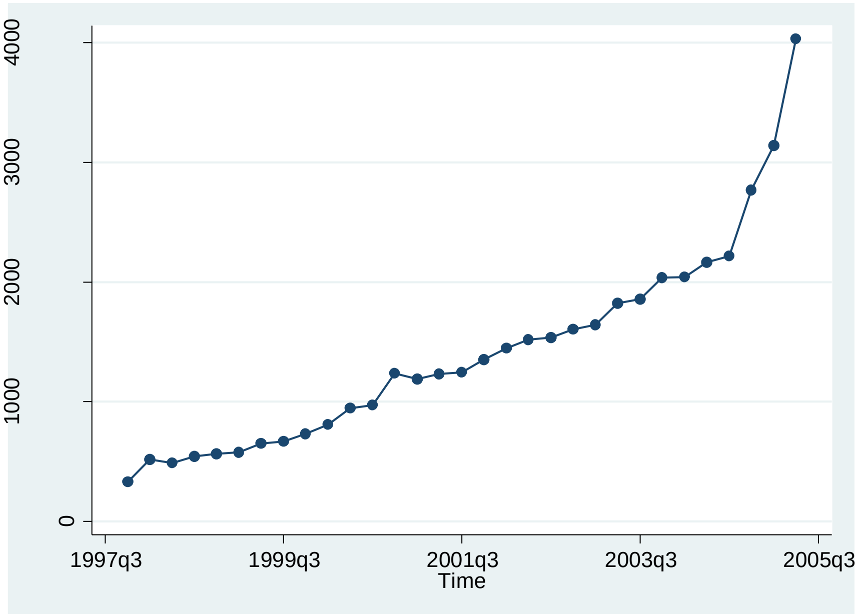

Figure 2.1 Average Cumulative Acquisition Spending

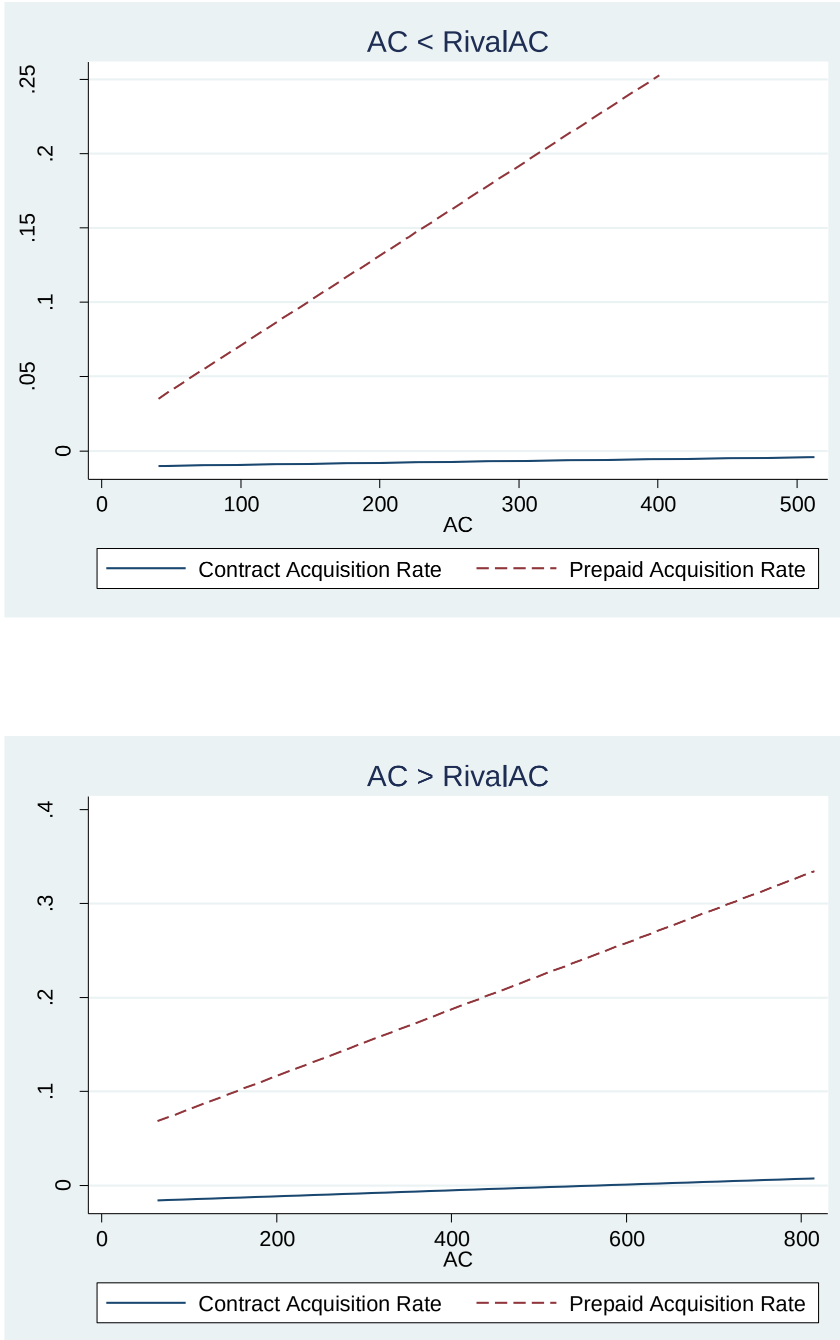

Figure 2.2 Acquisition Rate across Segments

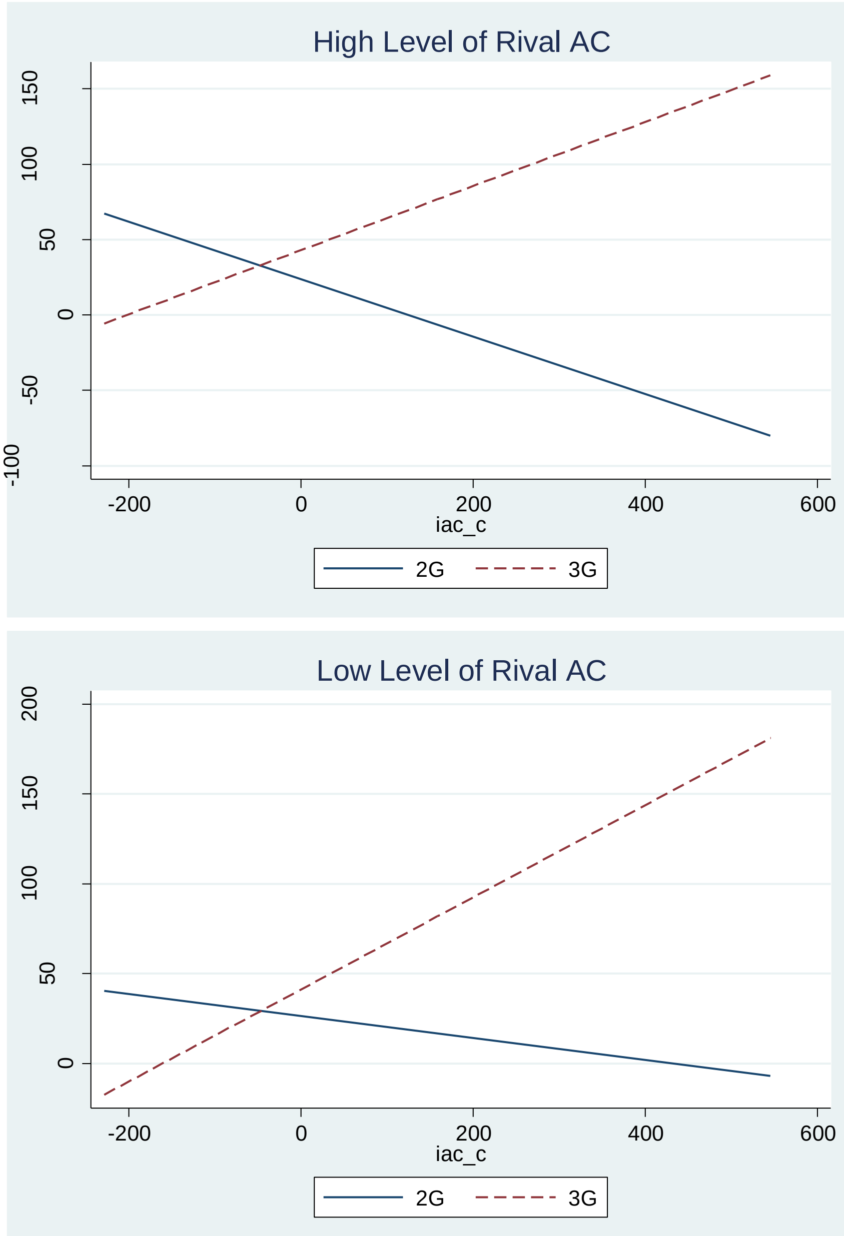

Figure 2.3 Moderating Effect of Rivals' Acquisition Spending

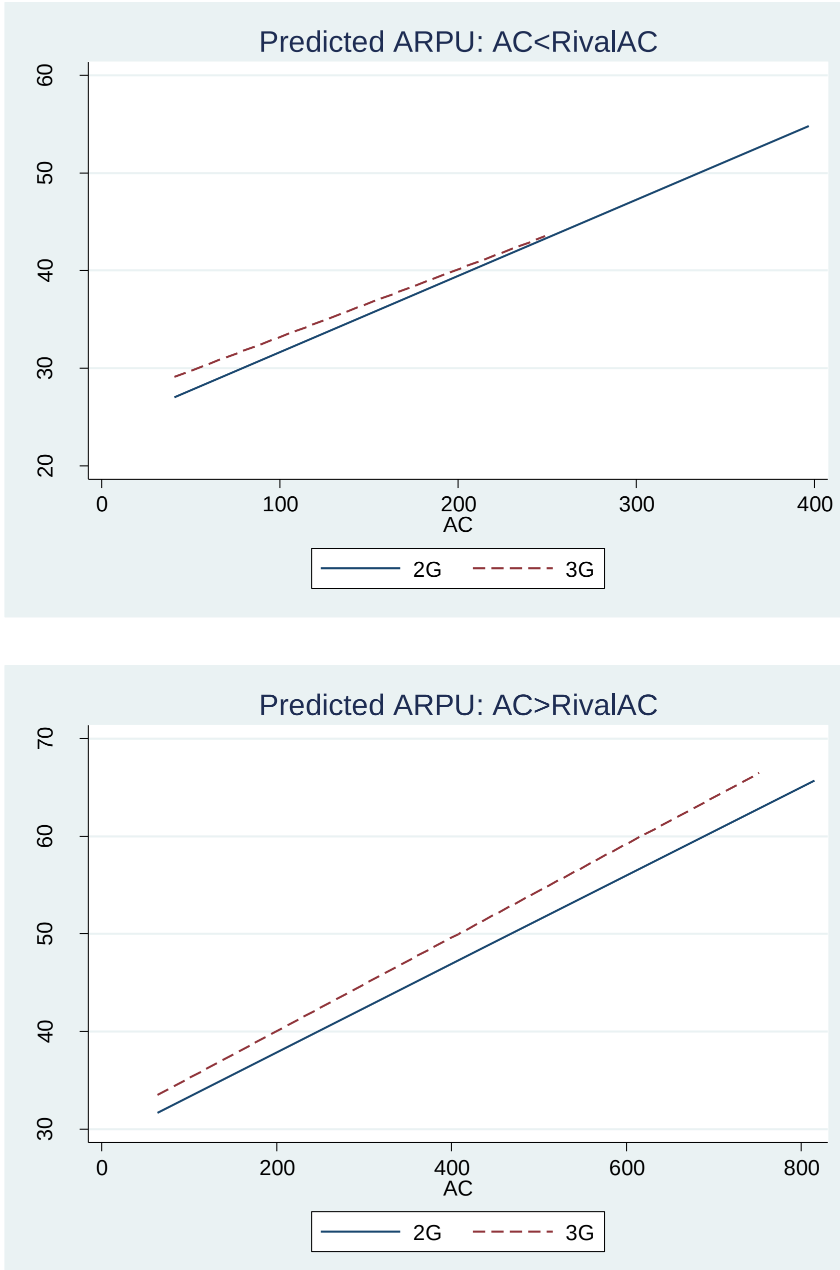

Figure 2.4 ARPU with different Technologies

References

Aiken, L.S., S.G. West. 1991. *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA: Sage.

Aksoy, L., B.C. Cooil, C. Groening, T.L. Keiningham and A. Yalcin. 2008. The Long Term Stock Market Valuation of Customer Satisfaction. *Journal of Marketing*, 72(4) 105-22.

Barney, J. 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(1), 99-120.

Boeker, W. 1991. Organizational Strategy: An Ecological Perspective. *Academy of Management Journal* 34(3) 613-635.

Boulding, W., R. Staelin, M. Ehret, M., W. J. Johnston. 2005. A Customer Relationship Management Roadmap: What is Known, Potential Pitfalls, and Where to Go. *Journal of Marketing*, 155-166.

Blattberg, R.C., G. Getz, J.S. Thomas. 2001. *Customer Equity: Building and Managing Relationships as Valuable Assets* (MA: Harvard Business School Press).

Bolton, R.N., P.C. Verhoef. 2004. The Theoretical Underpinnings of Customer Asset Management: A Framework and Propositions for Future Research. *Journal of the Academy of Marketing Science*, 32(3), 1-20.

Caminal, R., C. Matutes. 1990. Endogenous Switching Costs in a Duopoly Model. *International Journal of Industrial Organization* 8(3) 353-373.

Chandy, R., G. J. Tellis. 2000. The Incumbent's Curse? Incumbency, Size and Radical Product Innovation, *Journal of Marketing*, 64 1-17.

Chen, Y. 1997. Paying Customers to Switch. *Journal of Economics and Management Strategy*, 6(4) 877-897.

Conner, K. R. 1991. A Historical Comparison of Resource-Based Theory and Five Schools of Thought within Industrial Organization Economics: Do We Have a New Theory of the Firm? *Journal of Management* 17(1), 121-154.

Dekimpe, M. G., D. M. Hanssesns. 1999. Sustained Spending and Persistent Response: A New Look at Long-Term Marketing Profitability. *Journal of Marketing Research* 36, 397-412.

Dong, Y., Y. Yao, T.H. Cui. 2011. When Acquisition Spoils Retention: Direct Selling vs. Delegation under CRM. *Management Science* 57(7) 1288-1299.

Drucker, P.F. 1973. *Management.* New York: Harper & Row.

Federal Communications Commission (FCC). 2005, 2006. Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services, *Tenth/ Eleventh Report*.

Grant, A. W.H., L. A. Schlesinger. 1995. Realize Your Customers' Full Profit Potential. *Harvard Business Review* 58-72.

GSM Association. 2011. *European Mobile Industry Observatory 2011*.

Gupta, S., D.R. Lehmann, J.A. Stuart. 2004. Valuing Customers. *Journal of Marketing Research,* 7-18.

Gupta, S. and V. Zeithaml. 2006. Customer Metrics and Their Impact on Financial Performance. *Marketing Science*, 25(6).

Gustafsson, A., M. D. Johnson, I. Roos. 2005. The Effects of Customer Satisfaction, Relationship Commitment Dimensions, and Triggers on Customer Retention. *Journal of Marketing*, 210-218.

Hambrick, D. C. 1983. High Profit Strategies in Mature Capital Goods Industries: A Contingency Approach. *The Academy of Management Journal* , 26(4) 687-707.

Hausman, J., J. Wright. 2006. Two Sided Markets with Substitution: Mobile Termination Revisited. MIT working paper.

Hausman, J. 2002. Mobile Telephone. *Handbook of Telecommunications Economics* (Amsterdam: Elsevier Science), 1, 563-603.

Jansen, J.J, F.A.J. Van Den Bosch, H.W. Volberda. 2006. Exploratory Innovation, Exploitative Innovation, and Performance: Effects of Organizational Antecedents and Environmental Moderators. *Management Science*, 52(11) 1661-1674.

Miller, D. 1987. The Structural and Environmental Correlates of Business Strategy. *Strategic Management Journal*, 8, 55-76.

Neslin, S. A., S. Gupta, W. Kamakura, J. Lu, C. H. Mason. 2006. Defection Detection: Measuring and Understanding the Predictive Accuracy of Customer Churn Models. *Journal of Marketing Research* 43 (2), 204-211.

Morgan, N. A. 2012. Marketing and Business Performance. *Journal of the Academy of Marketing Science* , 40(1) 102-119.

Ramaswami, S. N., R. K. Srivastava, M. Bhargava. 2009. Market-based Capabilities and Financial Performance of Firms: Insights into Marketing's Contribution to Firm Value. *Journal of the Academy of Marketing Science*, 37(2) 97-116.

Reinartz, W., J.S. Thomas, V Kumar. 2005. Balancing Acquisition and Retention Resources to Maximize Customer Profitability. *Journal of Marketing*, 69, 63-79.

Reichheld, F.F. 1996. *The Loyalty Effect*, Harvard Business School Press, Boston, Massachusetts.

Reichheld, F.F., W.E. Sasser. 1990. Zero Defections: Quality Comes to Services, *Harvard Business Review*, September-October, 105-111.

Rust, R.T., K.N. Lemon and V.A. Zeithaml. 2004. Return on Marketing: Using Customer Equity to Focus Marketing Strategy. *Journal of Marketing* , 68(1) 109–27.

Shugan, S.M. 2005. Brand Loyalty Programs: Are They Shams? *Marketing Science*, 24(2).

Slater, S. F., J.C. Narver. 1994. Does Competitive Environment Moderate the Market Orientation-Performance Relationship? *Journal of Marketing*, 58, 46-55.

Song, M., Droge, C., Hanvanich, S. and Calantone, R. 2005. Marketing and Technology Resource Complementarity: An Analysis of Their Interaction Effect in Two Environmental Contexts. *Strategic Management Journal* , 26, 259–276.

Thomas, J. S. 2001. A Methodology for Linking Customer Acquisition to Customer Retention. *Journal of Marketing Research*, 38(2) 262-268.

Zahra, S. A., J. G. Covin. 1993. Business Strategy, Technology Policy and Firm Performance. *Strategic Management Journal* 14 (6) 451-78.

Zahra, S.A., W.C. Bogner. 1999. Technology Strategy and Software New Ventures' Performance: Exploring the Moderating Effect of Competitive Environment. *Journal of Business Venturing*, 15, 135–173.

Zineldin, M. 2006. The Royalty of Loyalty: CRM, Quality and Retention. *Journal of Consumer Marketing*, 23(7), 430-437.

This chapter, in full, is co-authored with Kevin Zhu. The dissertation author was the primary author.

Chapter 3

Does Pro-competition Policy Achieve the Intended Consequence? Evidence from Mobile Number Portability

Abstract

Does public policy designed to promote market competition indeed achieve the intended consequence? Using the mobile number portability (MNP) policy in the wireless industry as the testing field, this article examines this question by focusing on the impact of MNP on market prices. With panel data of 40 wireless operators in 9 countries over 8 years (1997-2005), we find that on average MNP has a negative effect on price; this effect is more pronounced in lagged periods. We also find that the power of contracts as a lock-in device is weakened by MNP. To probe into possible asymmetric effects, we analyze MNP impacts across firms (by market position) and across countries (by industry maturity). Interestingly, contrary to the policy intention to promote market competition, MNP does not necessarily make small firms better off. Further, MNP is more effective in countries with low cellular penetration rate, suggesting the need to implement the policy at early stages of industry maturity. Overall, this study uncovers the possible unintended, asymmetric consequences of industry policy, and provides insights into how firms compete in a regulated environment.

3.1 Introduction

For customer-centric businesses often affected by customer switching, such as wireless telecommunications, it is critical to understand and manage switching costs (Shapiro and Varian, 1999). This is particularly important when government regulations are introduced to affect switching costs. For example, Mobile Number Portability (MNP) is a regulatory policy aimed at reducing customer switching costs and promoting market competition in the wireless telecom industry (FCC, 2004).

By allowing customers to transfer phone numbers when changing wireless operators, MNP tends to eliminate "social network switching costs," a major barrier to switching due to the need to inform one's social networks (e.g., friends and business contacts) (Park, 2007).[1] Hence, a common belief is that MNP facilitates customer switching, intensifies competition and drives down market price (Lee et al., 2006). Meanwhile, it is unclear whether this presumption is true and whether the intended objective of the MNP policy is achieved.

Indeed, customer switching did not seem to surge immediately after MNP in many markets.[2] This observation suggests that firms (wireless operators) may have

[1] MNP also prevents the hassle to retype contact directories in new handsets and change payment arrangements. Although it does not eliminate all switching costs, the overall switching costs are lower relative to non-portability, all else being equal.

[2] For example, it was expected that 30 million customers would switch during the first year of MNP in the U.S. (2003-2004). However, it turned out that there were only 7.8 million (FCC 2005).

adjusted their customer strategies in response to MNP, so the net effect of the policy is reduced. For example, wireless operators can generate contractual switching costs by locking customers into longer contracts through heavier handset subsidies. The question is, to what extent can such strategy moderate the MNP effect? In other words, how much of the change in price and competition can be attributed to the policy? This is a research question we intend to explore. Gauging the effect of MNP is a significant research topic, because it evaluates whether the goal of the government intervention is achieved, and how wireless operators can manage switching costs to compete in a regulated, technology-intensive environment.

Regarding various switching costs related to firms' customer strategy, theoretical literature predicts that their impact on price depends on whether they are paid by firms or by customers (Caminal and Matutes, 1990). Hence, switching costs of different sources should be distinguished, so that their roles in the MNP outcome can be understood. Specifically in the wireless industry, it is important to separate contractual switching costs, a most prominent switching costs incurring to customers due to contract obligations. Yet this has not been done in existing empirical studies so far.

Many wireless operators, especially large incumbents, resist the policy in fear of market share erosion (Drucker, 2003). In fact, how does the impact of MNP on large firms differ from that on small firms? Given MNP's intention to enhance competition and facilitate the growth of small firms, it is important to identify real "winners" of the regulation, and explore possible mechanisms driving the consequence.

Besides firm-level characteristics associated with market position, industry maturity may also contribute to heterogeneous MNP outcomes (Aoki and Small, 1999). However, existing research on MNP is constrained to an individual market (e.g., Lee et al., 2006; Park, 2007) due to the lack of comparable international data. Along this line, a cross-country study is suggested as an interesting research opportunity (Buehler et al., 2006). In response, we seek firm-level evidence from the global wireless industry, thus bring an international dimension to the literature of policy analysis.

To summarize, we study the following research questions: (1) How does MNP affect market prices? (2) How do contractual switching costs moderate the MNP effect? (3) How does the MNP effect (if any) vary across firms and countries?

To address these issues, we develop a model grounded in the switching costs literature, and estimate it with a panel dataset of 40 firms in 9 countries over 8 years (1997-2005). Our empirical study differs from the existing literature because it investigates MNP effect along two dimensions: large versus small firms, and mature versus less mature industries. This helps uncover possible asymmetric effects of the policy. Also, it addresses MNP lagged effects, contrary to prior studies that focus only on its instantaneous impact. Furthermore, we distinguish contractual switching costs, which are the most prominent switching costs and can be managed by firms, and incorporate its moderating role in the MNP effect.

The rest of the article is organized as follows. We first provide a theoretical background with a literature review on switching costs, especially that related to MNP.

Then we address the research questions and lay out corresponding hypotheses. These are followed by data description, empirical analysis and discussion of results. We conclude with key findings, contributions and extensions.

3.2 Theoretical Background and Hypotheses

In this section, we identify and discuss potential factors contributing to MNP effect with a theoretical foundation and propose hypotheses accordingly. This revolves around our central research question, i.e., how an exogenous change in switching costs induced by MNP, coupled with the endogenous contractual switching costs, would affect prices.

3.2.1 Switching Costs

Switching costs are usually assumed to be exogenous in classic models (e.g., Klemperer, 1987a, b); they can create *ex post* market power, because customers may be locked in to a firm once they purchase its product or service (Klemperer, 1987a, b). Such lock-in decreases market competition, and possibly leads to higher prices, revenues and profits. In this respect, switching costs are socially undesirable, which may justify policy interventions to reduce switching costs and promote competition (e.g., Klemperer, 1995).

The mobile number portability regulation is one such policy to decrease switching costs exogenously. Studies on MNP are mainly based on a key testable prediction of the theoretical literature on switching costs (see Farrell and Klemperer, 2007 for a review). That is, lower switching costs are associated with more frequent switching, lower price and greater competition. Corresponding empirical evidence is consistent with this prediction. For instance, in the U.S. wireless industry, prices decrease after MNP, and the decline is larger for higher-volume users, who incur greater social network switching costs and thus benefit more from MNP (Park, 2007). Under wireless network-differentiated price discrimination (Shi et al., 2006), or in a similar context of 1-800 toll-free telephone services (Viard, 2007), number portability is also found to be associated with lower prices. Therefore, we also expect that on average MNP has a negative impact on prices.

The important role of switching costs in competition suggests that firms can benefit from actions that affect customer switching costs. Specifically, firms can endogenously create switching costs to lock in customers, whether through real switching costs such as discounts and coupons (Caminal and Matutes, 1990), or contractual switching costs such as contracts (Fudenberg and Tirole, 2000). Indeed, whereas MNP reduces overall switching costs as an exogenous force, other sources of switching costs still exist (Lee et al., 2006), which might reduce the effectiveness of the policy.

Yet, few studies on MNP have explicitly incorporated such endogenous switching costs. In particular, the literature usually assumes that firms compete in spot prices with short term interactions, thus implicitly focusing on “real” social costs such as transaction costs, whereas contractual switching costs not regarded as social costs has received little attention (Farrell and Klemperer, 2007). However, firms have an incentive to create contractual switching costs through long-term contract lock in (Fudenburg and Tirole, 2000); particularly, contracts are crucial to prevent customers from switching in the wireless industry (Gerpott et al., 2001). Therefore, it is useful to separate contractual switching costs in the present setting.

In analytical models of switching costs, a firm's price is increasing in the captivity of its customers (Chen, 1997; Stango, 2002). To increase this captivity, wireless operators often attempt to lock in existing customers through service contracts (typically for 1~2 years). If customers on contract switch out during the contract period, they will have to pay early termination fees, which incurs as what we call *contractual switching costs*. On the contrary, customers may purchase "pay-as-you-go" prepaid cards and can easily switch without any contractual obligation. Therefore, the extent to which a firm can create contractual switching costs depends on its customer composition. A higher percentage of customers on contract means greater captivity of existing customers and higher contractual switching costs. Even though customer captivity in these models is assumed to be a given parameter rather than a decision variable of firms, we can still apply the rationale of switching costs in a similar way. That is, since the key testable prediction of the theoretical literature on switching costs suggests that higher switching costs are associated with higher prices, the prediction should also hold when higher switching costs result from greater customer captivity. Further, industry evidence suggests that contract customers usually generate higher ARPU compared to prepaid customers (FCC, 2006). Therefore, we hypothesize that a higher percentage of contract customers, an indication of higher aggregate contractual switching costs, would make it easier for operators to lock in customers and charge higher prices.

While the direct effect of switching costs on prices is predicted to be positive, the theory provides little guidance as to the moderation effect of endogenous switching costs. We postulate that MNP would weaken this lock-in effect. All else being equal, MNP makes it easier for customers to switch out, though contracts are still important. Accordingly, prices would be negatively affected by the interaction effect of MNP and *contractual switching costs*.

3.2.2 Firm and Country Heterogeneity

Although switching costs are negatively related to prices in general, the result could be different, depending on firms' market positions (e.g., Klemperer, 1987a, b). The MNP may be against or in favor of market leaders (Aoki and Small, 1999). Theoretical models suggest that a decrease in switching costs would decrease not only prices, but also the price dispersion between large and small networks (Shi et al., 2006). This implies the larger network reduces prices more after MNP, making its subscription more attractive. Based on data from Hong Kong, Shi et al. (2006) observe that large firms actually gain larger market share and reduce prices more after MNP. Whereas their finding is interesting, formal econometric analysis is further needed to analyze how much this asymmetric effect is attributed to MNP as opposed to other factors. Also, their study was constrained in a regional market (Hong Kong) within a short time horizon (six months before and after MNP). Nevertheless, based on their theoretical prediction, we postulate that prices of larger firms decrease more than smaller firms.

Further, it remains a question whether the result of Shi et al. (2006) can be generalized to other countries with different market conditions, for example, where the wireless industry is not as mature as Hong Kong when MNP is introduced. In fact, the effect of a decrease in switching costs depends on the relative number of new and old customers on the market, and equilibrium prices decrease with the size of the new segments (e.g., Klemperer, 1987a, b; Farrell and Shapiro, 1988). In growing markets with high proportion of new customers, reduced switching costs are more likely to intensify competition and lower prices, as firms pay more attention to attract new customers (e.g., Shi et al., 2006). Therefore, we predict that the price effect of MNP is greater in countries with high penetration rate than those with low penetration rate.

Combing both firm and country heterogeneity, we make further predictions as follows. With a decrease in switching costs, MNP would make larger networks even more attractive in markets with more new users; i.e., MNP leads to greater decrease in price dispersion between large and small firms in the growing market (Shi et al., 2006). Therefore, we hypothesize that in mature markets with few new users, large firms would reduce prices more than small firms after MNP, while in growing markets the decrease in price dispersion may not be as evident. In other words, we postulate that MNP is more effective in countries higher penetration rate.

3.3 Data and Variables

We use a quarterly panel dataset of 40 major wireless operators over 8 years (1997Q4 – 2005Q2) in 9 countries from the EMC World Cellular Database.[3] Further, we obtain country-level statistics from the Global Market Information Database. During the sample period, MNP was introduced in 8 out of the 9 countries at different cellular penetration rates (Table 3.1). The panel is unbalanced, as data are not equally available for each operator across all variables. The definitions of firm-level variables are described below.

3.3.1 Dependent Variable

We specify *Average Revenue per User* (ARPU) as a proxy for prices, which serves as the dependent variable in our model. It includes subscription fees, voice and data charges, outbound roaming fees, and interconnection fees on the per-user basis.[4] A direct measure of price would be more desirable, yet there is no simple measure of prices in the wireless industry, due to the complicated nonlinear pricing scheme such as three-part tariffs (Parker and Roller, 1997) and great variations in non-price terms of calling plans (FCC, 2004-2008).[5] ARPU can be regarded as a price proxy if the interest is not per-minute price, but the total price of service bundles (McCloughan and Lyons, 2006).[6]

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[3] Countries include Australia, Canada, France, Germany, Korea, Singapore, the U.K., and the U.S.

[4] It does not include customer acquisition costs.

[5] Also, "pricing analysis is further complicated by the addition on bills of recurring monthly line items charged by wireless carriers, separated from the advertised month rates" (FCC 2008).

[6] This is a common consideration of purchase decision especially for contract customers. For example, data

Moreover, ARPU is widely used as a key performance indicator (KPI) in the wireless industry (Gruber, 1999). It has also been a major measure of market performance used by regulators and by the International Telecommunication Union (ITU) (FCC, 2004-2008).

3.3.2 Explanatory Variables

We include the following explanatory variables. *MNP* is the regulation dummy which equals to “1” if MNP is implemented and “0” otherwise. *Contract Customers%* is the percentage of customers on contract for an operator, a measure of its aggregate contractual switching costs (for switching out).

The descriptive statistics of these variables are shown in Table 3.2. From a simple mean comparison before and after MNP, ARPU decreases after MNP (significant at 1% level). However, we cannot tell whether the change is attributed to MNP or the general time trend, or both. Also, this only reports the average change and does not show whether the change would possibly differ across firms and countries.

3.3.3 Controls

Furthermore, we control for other factors that may also affect ARPU. First, wireless operators use different network technologies, which may contribute to ARPU differently. We distinguish six major standards in the wireless evolutional history, including Analogue, Global System for Mobile Communications (GSM), Code Division

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service are usually not priced on a per-minute basis; contract customers usually focus on monthly bills as a whole rather than attempting to interpret mobile tariff schedules; handset subsidies and cash rebates are important considerations of service bundles purchase, which are not based on per-minute pricing.

Multiple Access (CDMA), Time Division Multiple Access (TDMA), Wideband CDMA (WCDMA) and CDMA2000. Second, heterogeneity in industry characteristics and national demographics may influence the relationships as well. Cellular penetration rate, which represents industry maturity level, may affect ARPU (McCloughan and Lyons, 2006). This effect is expected to be negative, because in the early stage of the industry customers are usually business users with high usage and low price elasticity, contributing to high ARPU, whereas ARPU declines as market saturates and more low-usage customers are attracted by low prices (Gruber, 1999). Also, countries with higher percentage of young and highly educated people may have greater demand for cellular services (Wareham et al., 2004). Therefore, we include four country-level controls: number of cellular subscribers per 100 inhabitants (*Cellular Penetration*), percentage of 20-39 age group (*Young*), percentage of 13-19 age group (*Teen*), and percentage of people with high education (*High Education*).

3.4 Empirical Analysis

3.4.1 Baseline Model, Identification and Estimation

In a simple difference-in-difference baseline model, ARPU of wireless operator *i* in country *j* at quarter *t* is estimated as a function of MNP:

$$ARPU_{ijt} = \alpha_1 + \beta_1 MNP_{ijt} + \phi' Z_{ijt} + \theta' W_{jt} + \gamma_t + u_i + \nu_j + \varepsilon_{ijt} \qquad (1)$$

where column vector Z_{ijt} contains the firm-level controls and W_{jt} has the exogenous country-level variables; u_i and ν_j are time-invariant firm- and country-fixed effects, respectively; γ_t accounts for seasonality, country-specific time trend and its quadratic; and ε_{ijt} is the error term not captured by the regressors.

The key variable of interest is MNP. The main hypothesis is whether $\beta_1>0$ or $\beta_1<0$. In most countries, MNP is mandated simultaneously for all wireless operators at once, and thus can be regarded as an exogenous policy shock.[7] To mitigate the potential endogeneity of MNP, we use country fixed effects model, so that the timing of MNP introduction, conditional of country fixed effects and time trend, is assumed to be exogenous. We also adjust standard errors for panel-level heteroskedasticity and autocorrelation. For OLS estimation (Column 1 of Table 3.3), the negative and significant coefficient on MNP ($\beta_1 = -1.719$, $p < 1\%$) suggests that on average MNP is associated with lower ARPU (3.9% decrease). As the average quarterly change in ARPU before MNP is a decrease of 0.9% in the sample, we infer that the MNP impact is substantial.

The coefficients of country-level controls have expected signs in both estimations. Firms in countries with high cellular penetration rates are associated with lower ARPU,

[7] This exogeneity assumption deserves a more careful look. In some countries, MNP is implemented sequentially, i.e., allowing only one-way porting at one time. For instance, in Korea MNP was first imposed to the largest operator (SK Telecom), whose customers could switch to other smaller operators but not the other way around. In such cases, governments have concern over monopoly and market concentration. Yet, this could be a two-way relationship. Large firms usually argue against MNP, concerned about loss of customers. As firms can potentially influence the outcome of regulatory policies, large firms may lobby the government with stronger anti-MNP pressure, thus influencing the policy implementation. For example, in the U.S. MNP was postponed from 1999 till 2003, with the deadline extended three times. Which effect dominates varies across countries; either direction raises the question about potential endogeneity of MNP.

possibly due to saturated market demand as industry matures. Also, ARPU is higher in countries with younger and better educated population, which includes heavy users of cellular services, especially value-added data services.

3.4.2 Main Specification, Identification and Estimation

In light of the discussion in Sections 3.2 and 3.3, one might expect that the change in ARPU due to MNP may differ across firms, depending on their customer base composition as a result of contractual switching costs. Hence, our next step is to allow MNP to affect ARPU by different proportions due to contract lock-in, i.e., adding to Model (1) the interaction term between *Contract Customers%* and *MNP*:

$$\begin{aligned} ARPU_{ijt} = {} & (\alpha_1 + \beta_1 MNP_{ijt}) + (\alpha_2 + \beta_2 MNP_{ijt}) \times ContractSubscribers\%_{ijt-1} \\ & + \phi' Z_{ijt} + \theta' W_{jt} + \gamma_t + u_i + \nu_j + \varepsilon_{ijt} \end{aligned} \tag{2}$$

We use lagged (previous quarter) rather than current quarter contractual switching cost variables as the explanatory variables.[8] This is based on the timing inherent in switching costs models in the literature that we described before. That is, the market equilibrium prices are firms' *ex post* price, after consumers' purchase and switching decisions, while variables of last period are *ex ante* considerations for firms when they set prices. This timing issue suggests that the effect of switching costs on the *ex post* prices takes on some lag. As robustness checks, we also use different lags of *Contract Customers%* in the regression, and find that it is significant up to lagged 7 quarters.

[8] We use contemporaneous rather than lagged controls. Results are similar when we use lagged controls.

Using lagged variables of *Contract Customers%* decreases the size of effective sample, but mitigates the endogeneity concerns that would be introduced by the specification of a relationship between current price and contractual switching costs, which apparently affect each other.[9] When comparing results using contemporaneous and lagged *Contract Customers%*, we find that the lagged variables have greater explanatory power than its contemporaneous counterparts. This may reflect the fact that prices depend on inherited lagged captivity of customers.

Nevertheless, to address possible endogeneity of lagged contractual switching costs in Model (2), we make use of the panel structure of the data, apply IV approach and perform endogeneity test. We instrument lagged *Contract Customers%* by the lagged percentage of teen aged population in a country. This is because prepaid plans, the opposite of contract plans, usually target customers unqualified in credit, such as teenagers. Therefore, higher percentage of teen aged population in a country would mean lower percentage of contract customers in general, which may enable higher prices in the next period; meanwhile, it is not obvious that this lagged country-level variable would directly affect contemporaneous ARPU through other channels. Hence, it is appropriate as an IV. The endogeneity test cannot rejects the null of exogeneity ($F(2, 38)= 1.17$, $p >$ 10%). Therefore, we use the consistent OLS estimation rather than IV estimation hereafter.

[9] Firms with higher ARPU may also be able to retain more customers on contract. Also, measurement errors may be involved in contractual switching costs, because contract early termination fee, a more accurate measure of contractual switching costs, is not available in the present data.

As can be seen from the second column of Table 3.3, the marginal effect of MNP, net of the moderation of *Contract Customers%* evaluated at the sample means, is still negative ($1.524 or 3.4% decrease in ARPU, at 1% significance level), indicating MNP does not favor ARPU. However, compared with Model (1), MNP effect is weaker, suggesting the moderating role of contractual switching costs.

Furthermore, the coefficient on lagged *Contract Customers%* has a positive coefficient, which confirms our prediction that greater percentage of customers on contract enables higher ARPU in the future. This is consistent with the theoretical prediction that greater switching costs are associated with higher prices. Specifically, it highlights the importance of increasing contractual switching costs to enhance customer captivity.

However, *Contract Customers%* generates a negative impact with MNP, as the MNP dummy in the curvature of *Contract Customers%* is significantly negative. Hence, the returns to firms with high percentage of contract customers fall proportionally more than the returns to those with low percentage of contract customers.

This result may be explained by the competitive effect of MNP. With phone numbers portable, customers have greater bargaining power over prices and terms to stay on contract with current wireless operators, hence driving down their ARPU. To this extent, the power of contracts as a lock-in device is weakened by MNP.[10]

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[10] An additional explanation is that, firms with more customers on contract may be subject to greater volatility of customer base, as MNP makes it easier for contract customers to switch than otherwise.

3.4.3 Lagged Effects of MNP

To capture possible time patterns of MNP effects, we replace the original single MNP indicator by 19 mutually exclusive indicator variables relative to the implementation of the policy: 1-8 quarters before/after MNP, 9 or more quarters before/after MNP, and the quarter of MNP in effect which is used as the omitted reference category. [11]

The time coefficients of MNP are graphed in Figure 3.1.[12] Before MNP there is a decreasing trend in ARPU 6 quarters and beyond; this turns to be increasing until 4 quarters after MNP. The instantaneous effect of MNP is first positive and becomes negative at 5th quarter, and the negative effect peaks in the 6th and 7th lagged quarters. This suggests that the effectiveness of MNP is delayed.

It is plausible that, in anticipation of the MNP mandate, firms increase resources on customer retention as precautions, possibly by offering longer term contracts through heavy sign-up subsidies, and giveaways of additional minutes and cash credits (FCC, 2004). Although many customers are enticed to take up these offers, some might not be aware of the impending MNP (Richtel, 2003). Taking this advantage, more long-term contracts may be signed up before the advent of MNP.[13] Therefore, we can expect that

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[11] We breakdown post-MNP periods up to lagged 8 quarters, as contract length is usually two years after MNP. We also include up to 12 quarter lags, and many of their coefficients are insignificant. Hence, we report only 8 quarter lags results.

[12] Similar patterns are obtained when quarterly time trend is used; hence the results are not reported.

[13] For example, in the U.S., "wireless companies are eager to sign customers to new one- or two-year deals before Nov. 24" in 2003, i.e., before MNP implementation (Richtel 2003).

the negative MNP effect is not prominent until the majority of these pre-MNP contracts expire and customers are more informed of the MNP policy. This explains the time pattern of the MNP effect.[14]

As a robustness check, we exclude observations of one-year after MNP in Models (1) and (2) (Appendix Table A3.1). The negative MNP effect is even stronger in both models compared with their respective baseline in Table 3.3, suggesting the decrease in ARPU may not be evident right after MNP. This confirms our previous results on the lagged pattern. Similarly, one-year before MNP observations are excluded as another robustness check.[15] The MNP effect is also stronger than the baseline. Hence, in anticipation of the policy, firms may have adjusted their strategies in a way to retain ARPU. This may have damped the MNP impact. Meanwhile, the marginal effect of MNP is stronger in Model (2) than Model (1) in both robustness checks. This is factually consistent with the baseline results that MNP effect is weaker in Model (2) than Model (1) when accounting for contract lock-in. Excluding "locked-in" observations one year before or after MNP plays down the role of contracts strategically signed up, which tend to reduce the MNP effect compared with the scenario without contract moderation.

[14] We also add time effects of MNP into Model (2). They are similar to those in Model (1).

[15] This is similar to accounting for the possible "Ashenfelter's Dip" before MNP, which might involve a decrease in ARPU shortly before the policy, presumably due to the anticipation of its implementation (e.g., cheaper plans that might lead to lower ARPU).

3.5 Asymmetric Effects of the Policy

As discussed in Sections 3.1 and 3.2, MNP effect could be different cross firms and countries. To identify potential "winners" of the regulation and the source of this asymmetry, we further explore our research questions by firm heterogeneity (market position) and country heterogeneity (industry maturity).

3.5.1 Market Position: Large vs. Small Firms

We separate "large firms" and "small firms", where the former refers the largest firm in each country with more than 50% market share, or the largest two firms if each has more than 30% market share at the initial sample period. The rest is counted as "small firms." The descriptive statistics suggests that the two groups are heterogeneous (Table A3.2). For example, ARPU decrease after MNP in both groups, but the extent is greater for small firms (1% significance level) and insignificant for large firms.

The IV estimation results are reported in the first two columns of Table 3.4. Most coefficients are consistent with the pooled regression, but their magnitudes vary by firm size. Surprisingly, the negative interaction effect of *Contract Customers%* with MNP is greater for small firms. Small firms on average have higher percentage of customers on contract (Table A3.2), and these customers gain bargaining power over prices after MNP. This induces greater pressure for small firms to compete with large firms. Similar to the pooled regression, acquisition costs do not significantly benefit large firms after MNP. However, it becomes marginally significant for small firms. This may imply that before

MNP, customer acquisition might not be critical for small firms as their markets are usually regional or niche segments. Yet MNP might have changed the industry competition, leveling the playfield in the sense that it enables the large firms to compete in these regional markets. This makes customer acquisition more important.

Finally, as shown at the bottom of Table 3.4, the marginal effect of MNP is on average \$3.26 (1.34%) decrease in ARPU for large firms (though not statistically significant), which is weaker compared with \$0.44 (2.2%) decrease for small firms (significant at 5% level). This implies that MNP does not seem to benefit small firms. This outcome is contrary to the policy intention to promote competition.

This surprising result might be explained by “network discriminatory pricing scheme” prevalent in the industry (Laffont et al., 1998). That is, a wireless operator charges a lower price for “in-net” calls (calls initiated and received within the same network) than for “off-net” calls (calls connected across different networks). Hence, a customer who subscribes to a larger network would benefit more than if subscribing to a smaller network. This effect may be magnified by MNP, which intensifies price competition for in-net calls, making subscription to a large network even more attractive. [16] Another possibility is the investment in porting technology imposes disproportionate burdens on small firms. If the cost of porting technology has to be recouped from a smaller customer base, it will delay network upgrades to provide value-added data services (FCC, 2004).

[16] For instance, in the U.S. firms offered more discounts for in-net calls since MNP, e.g., “unlimited in calls” by Verizon, and “free mobile-to-mobile calls” and “Family Talk” plans by AT&T.

3.5.2 Industry Maturity: Cellular Penetration Rate

So far, we use country-fixed effects to control for country heterogeneity. We may gain further insights if we examine specific industry characteristics across countries. In particular, MNP was introduced at different levels of penetration rates, which might be considered as an indicator of industry maturity (Table 3.1). To account for this, we interact *MNP* with *Cellular Penetration* as a modification to Model (2).

The results of IV estimation of this modified model are shown in Column 1 of Table 3.5. Again, most coefficients are robust to those of the baseline model. *Cellular Penetration* itself has a negative impact on ARPU, yet its interaction term with MNP turns out to be significantly positive. The interaction effect somewhat offsets the direct effect, indicating that firms in mature industries are affected less by MNP.

As the wireless industry matures, cellphone usage grows higher. With increased variety of data services enhanced by new technologies like the 3G, one can expect that more market demand migrates from basic voice services to value-added data services, such as multimedia messaging, email, mobile TV, and GPS navigation. More usage of these services thus enables firms to charge higher prices, offsetting the MNP impact. Second, wireless operators are likely to develop new lock-in strategies to retain customers in the presence of MNP (e.g., Shin, 2006). This is enhanced by more advanced technologies available in a mature industry. Third, as industry matures, customers have already switched several times and settled with operators that best match their needs.

Our finding suggests that the timing of MNP introduction is important in order to achieve its effectiveness, preferably at the early stage of industry maturity. To further confirm this result, we separate countries into two groups according to whether their cellular penetration is low or high at the time of MNP (Columns 2 and 3 of Table 3.5).[17] The marginal effect of MNP is 1.9% *decrease* in ARPU for firms in countries with low cellular penetration (significant at 5% level), and statistically insignificant for those in countries with high penetration. This again strengthens our inference that MNP is more effective in less mature countries.

3.5.3 Firm and Industry Heterogeneity

Results from the sample split in Section 3.5.2 reveal country heterogeneity based on industry maturity. Meanwhile, the estimates are average effects at the country level, not specific to firms with different market positions. For example, it is not evident whether the greater decrease of prices in low penetration countries is attributed to a substantial decrease of prices for large or small firms, and whether the case is the opposite in high penetration countries.

To probe deeper into how market position and industry maturity may jointly drive the MNP effect, we further split the sample into 2x2 groups, i.e., large/small firms in low/high penetration countries. The estimation of Model (2) for each group shows that

[17] We use 60% as the cutoff point of low and high cellular penetration rate. A *t*-test of sample mean shows that the minutes of use per user is greater for high penetration countries (392 minutes) than low penetration countries (205 minutes), and the difference is significant at 1% level. This confirms the interpretation in the previous paragraph.

the signs of all the coefficients remain the same as before. In terms of the marginal effect of MNP (shown at the bottom of Table 3.6), large firms in low penetration countries seem to be real “losers” of MNP (10.19% decrease in ARPU), while small firms in those countries do not seem to be affected (1.24% decrease in ARPU, insignificant). In contrast, small firms in high penetration countries decrease significantly 4.46% in ARPU, while large firms are not affected (5.88% decrease in ARPU, insignificant).

The result is consistent with what we find in Section 5.2. After MNP, countries with less mature industry not only have overall lower prices, but also less price dispersion in favor of small firms. This again seems to run contrary to prior beliefs that MNP is more effective in more mature markets.

To further demonstrate both firm and country variation, we graph the time pattern of MNP effect for the sample split. As can be seen from Figure 3.2, in low penetration countries, the balancing effects of contract lock-in one year before/after the policy implementation is not as evident as in high penetration countries. Further, in those countries large firms are affected to the similar extent or even more than smaller firms. This could result in price convergence between large and small firms. Meanwhile, the opposite pattern is observed in countries with high cellular penetration rate. While small firms are affected more by MNP, large firms are less affected. This would lead to greater price dispersion among firms. Together, the results confirm our previous finding about country heterogeneity, and suggest that the interpretation about firm heterogeneity should be considered under the context of specific industry maturity.

3.6 Discussion and Conclusions

Switching costs coupled with technological change are of strategic importance to manage customer behavior in the wireless industry. This becomes even more interesting when government policies are involved. These policies are expected to improve market efficiency and social welfare (Hazlett and Munoz, 2009). Taking MNP as an example, it is designed to level the play field and promote technology innovation by reducing customer switching barrier. As governments and industries around the globe weigh the pros and cons of MNP, a fundamental question arises: Will public policy designed to promote market competition indeed achieve the intended consequence? What lessons might be learned from the MNP experiment?

Drawing upon relevant theoretical perspectives, we develop a model to investigate how a reduction in switching costs due to MNP, together with endogenous switching costs, would affect market price. Our empirical results identify the moderating role of switching costs, and unveil how MNP effect varies across firm size, technological standards and countries.

By doing so, this article makes several contributions to the literature. First, it uncovers the effect of a regulation that reduces a significant barrier to switching in the wireless industry. Instead of treating the policy as exogenous as in the literature, we correct for its endogeneity and find the MNP effect would have been overestimated otherwise. Hence, we conclude that MNP is far less effective than expected by policymakers. Also, we examine the MNP impact over time, and show that MNP takes effect in lagged periods, possibly cushioned by firms' strategic management of contractual switching costs in response to the policy.

Second, whereas MNP analysis in the literature has not incorporated different endogenous switching costs, we fill the gap by looking at the interplay between MNP and firms' customer strategies. By distinguishing transaction costs and contractual switching costs, we find that they differ in moderating the MNP effect: (1) customer acquisition investment does not guarantee higher price after MNP; and (2) the power of contracts as a lock-in device is weakened by MNP. An implication follows that in order to compete effectively in a regulated environment, firms need to adjust the focus of switching costs management, paying more attention to non-contract retention efforts rather than relying on contract and acquisition investment. Industry analysis indicates that customer acquisition costs in the wireless industry are 30-35% higher than the cost to keep existing customers (Grayson, 2008). As customer switching is substantial, this further emphasizes the importance of contract mechanism. Meanwhile, MNP reduces the effectiveness of contract lock-in, suggesting that other forms of customer retention effort are also important.

Third, our study sheds light on the *asymmetric effects* of MNP by extending firm-level analysis to an international context. Whereas most MNP studies are limited to an individual market, our global data set enables an international dimension to tease out cross-country differences in industry characteristics. Given the source of asymmetric effects remains an empirical question, we investigate it along three dimensions and find that: (1) contrary to the goal to level the play field, MNP does not necessarily make small firms better; (2) it does provide an opportunity for the entrant technology to compete, yet (3) this opportunity may still be better seized by large firms instead of small firms, which seems to run contrary to prior beliefs that small firms lead technology innovation; and (4) MNP is more effective in less mature industries. These results highlight the MNP outcome against its policy intentions, and identify possible “winners” and “losers” of the policy. Also, learning from the experience of MNP countries can be helpful for policymakers in non-MNP countries to carefully consider the implementation of the policy. Therefore, our cross-country analysis offers important policy implications absent in individual market studies.

This paper leaves several directions to explore in future research. In particular, the asymmetric impact on large and small firms helps us posit that MNP changes industry competition, possibly through market share reallocation. Yet the mechanism remains unclear. It will be useful to unravel the mechanism through which MNP would shape the evolution of industry competition, and whether it provides an equal opportunity for small firms. Another possible extension is the impact of MNP on innovation, in terms of technology advancement and product and service improvement, which are crucial aspects of non-price competition in this technology-intensive industry.

Overall, to the best of our knowledge, this article is the first to question the possible endogeneity of MNP, unfold its lagged pattern, and unravel its asymmetric effects in a cross-country context. We believe that our study advances the literature in this area; and it is useful not only for policymakers to assess the effectiveness of the regulation, but also for firms to understand how to incorporate customer switching into competitive strategies to sustain performance. With MNP as an experiment in the testing field of wireless industry, our approach can be further extended to analyze other public polices, and in other industries.

Table 3.1 MNP across Countries

Country	MNP Implementation Time	Cellular Penetration at MNP
Singapore	April 1997	23.77%
United Kingdom	January 1999	46.41%
Spain	October 2000	70.12%
Australia	September 2001	60.93%
Germany	November 2002	76.81%
France	January 2003	70.61%
United States	November 2003	61.12%
Korea	January 2004	77.70%

Table 3.2 Descriptive Statistics of Firm-level Variables (N = 951)

Variable	Total Average	Before MNP	After MNP	
Average Revenue per User	42.9367	44.524	40.455	***
($)	(13.449)	(13.898)	(12.3301)	
Contract Customers %	80.494	87.623	69.350	***
	(22.290)	(16.817)	(25.077)	

Standard deviations are in parentheses.
*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.

Table 3.3 Estimation Results

	Model (1)	Model (2)
MNP	-1.719***	0.786
	(0.569)	(1.037)
Contract Customers%		0.052
		(0.034)
MNP*Contract Customers%		-0.035***
		(0.012)
Cellular Penetration	-0.224***	-0.214***
	(0.051)	(0.053)
Young	5.537***	5.528***
	(1.094)	(1.009)
High Education	10.372***	10.828***
	(1.565)	(1.525)
Constant	-115.061***	-114.797***
	(34.401)	(32.128)
Observations	922	913
R^2	0.935	0.939
Marginal effect of MNP	-1.719***	-1.524***
	(0.569)	(0.570)

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.

Dependent variable in all regressions is *Average Revenue per User*.

Panel-corrected standard errors are in parentheses for fixed effects models.

All regressions include country-specific time trend and its quadratic, seasonality, six standard dummies and country-level controls.

Table 3.4 Robustness

	Market Position	
Explanatory Variable	Large Firms	Small Firms
MNP	-2.334*	5.060***
	(1.371)	(1.446)
Contract Customers%	0.023	0.074**
	(0.067)	(0.035)
MNP*Contract Customers%	-0.013	-0.064***
	(0.018)	(0.016)
Cellular Penetration	-0.095	-0.253***
	(0.124)	(0.059)
Young	11.343***	4.193***
	(1.319)	(1.296)
High Education	11.412***	8.915***
	(2.184)	(1.946)
Observations	252	661
R^2	0.907	0.926
Marginal effects of MNP	-3.260***	-0.442
	(1.034)	(0.623)

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions are estimated by IV.
Dependent variable in all regressions is *Average Revenue per User*.

Table 3.5 Country Heterogeneity

	Cellular Penetration		
Explanatory Variable	Overall	Low	High
MNP	-12.539***	-0.999	-0.452
	(3.020)	(1.616)	(1.177)
Contract Customers%	0.100***	0.147***	0.039
	(0.030)	(0.055)	(0.038)
MNP*Contract Customers%	-0.008	-0.013	0.010
	(0.012)	(0.017)	(0.018)
Cellular Penetration	-0.309***	-0.030	-0.073
	(0.050)	(0.104)	(0.091)
MNP*Cellular Penetration	0.199***		
	(0.040)		
Young	7.348***	9.509***	-2.490
	(1.022)	(1.979)	(2.069)
High Education	8.825***	13.113***	-14.460***
	(1.564)	(1.557)	(5.302)
Observations	913	620	293
R^2	0.979	0.977	0.992
Marginal effect of MNP	-1.646***	-2.086***	0.277
	(0.602)	(0.695)	(0.847)

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions are estimated by IV.
Dependent variable in all regressions is *Average Revenue per User*.

Table 3.6 Country and Firm Heterogeneity: 2x2 Sample Split

	Low Penetration Countries		High Penetration Countries	
Explanatory Variable	Large Firms	Small Firms	Large Firms	Small Firms
MNP	-1.931	2.603	-0.548	-0.194
	(2.420)	(2.224)	(1.158)	(1.584)
Contract Customers%	0.095	0.108*	-0.058	0.040
	(0.099)	(0.057)	(0.056)	(0.043)
MNP*Contract Customers%	-0.034	-0.036	-0.018	0.024
	(0.029)	(0.023)	(0.025)	(0.022)
Cellular Penetration	0.110	-0.075	-0.795***	0.063
	(0.223)	(0.110)	(0.202)	(0.106)
Young	13.507***	4.193**	1.086	-3.675
	(1.644)	(1.733)	(3.670)	(3.729)
High Education	13.507***	4.193**	1.086	-3.675
	(1.644)	(1.733)	(3.670)	(3.729)
Observations	151	469	101	192
R^2	0.973	0.964	0.971	0.944
Marginal effects of MNP	-4.408***	-0.676	-1.734	1.495
	(1.416)	(0.741)	(1.127)	(1.023)

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions are estimated by IV.
Dependent variable in all regressions is *Average Revenue per User*.

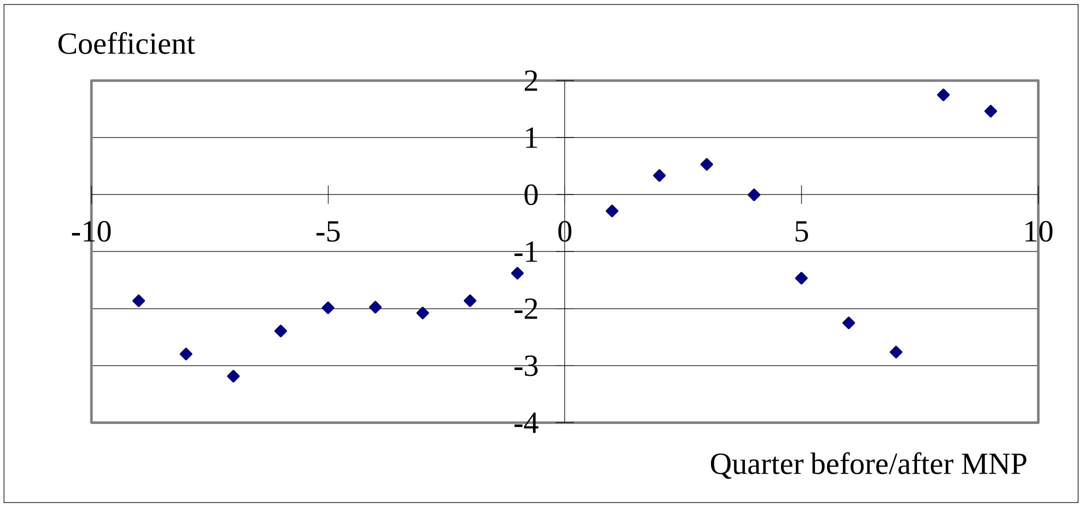
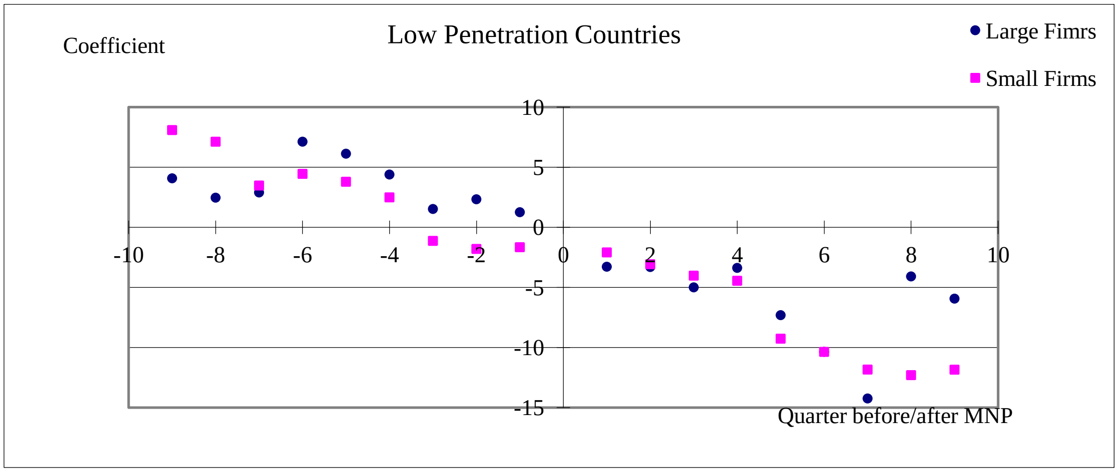


Figure 3.1 Time Pattern of MNP Effects



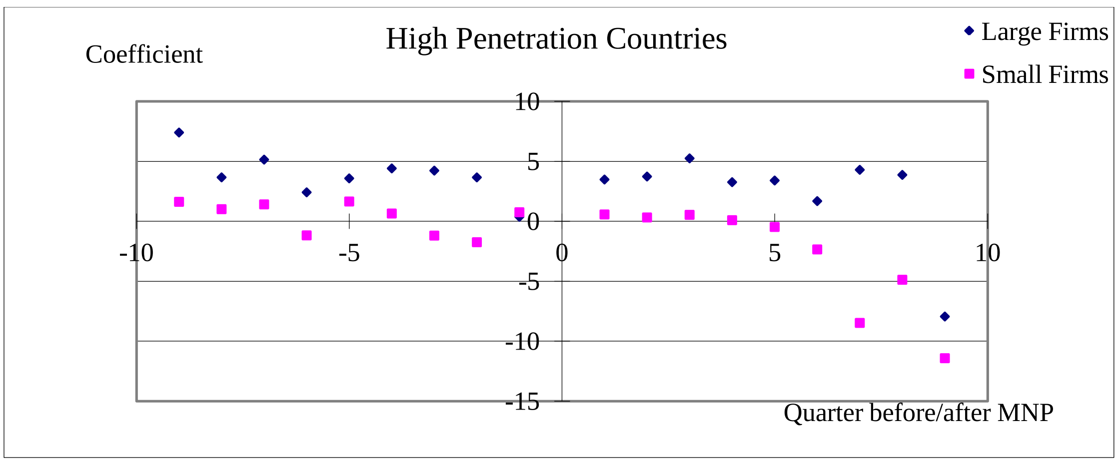


Figure 3.2 Time Pattern of MNP Effects: Firm and Country Variation

Appendix

Table A3.1 Robustness

	Excluding One-Year before MNP		Excluding One-Year after MNP	
Explanatory Variables	Model (1)	Model (2)	Model (1)	Model (2)
MNP	-3.406***	11.976***	-5.341***	12.548***
	(1.160)	(2.985)	(1.366)	(3.053)
Contract Customers%		0.135***		0.142***
		(0.036)		(0.036)
MNP*Contract Customers%		-0.202***		-0.260***
		(0.042)		(0.045)
Cellular Penetration	-0.267***	-0.321***	-0.196***	-0.220***
	(0.057)	(0.050)	(0.052)	(0.054)
Young	5.032***	5.412***	6.975***	7.327***
	(1.160)	(1.011)	(1.174)	(1.126)
High Education	7.526***	7.083***	8.673***	8.522***
	(1.656)	(1.611)	(1.768)	(1.780)
Observations	811	803	779	770
R^2	0.9345	0.9234	0.9325	0.9071
Marginal effects of MNP	-3.406***	-4.250***	-5.341***	-8.401**
	(1.160)	(1.168)	(1.366)	(1.537)
Change in ARPU (%)	-7.650%	-9.545%	-11.996%	-18.869%

*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.
All regressions are estimated by IV; dependent variable in all regressions is *Average Revenue per User*.

Table A3.2 Sample Mean: Large versus Small Firms

	Large Firms			Small Firms		
	Before MNP	After MNP		Before MNP	After MNP	
ARPU ($)	35.7856	36.346		47.253	43.1823	***
	(9.536)	(9.671)		(13.927)	(13.1423)	
Contract	81.9167	57.266 (18.908)	***	89.404	77.369	***
Customers %	(14.934)			(16.990)	(25.484)	
Observations	138	148		442	223	

Standard deviations are in parentheses.
*, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.

References

Aoki, R., J. Small, J. 1999. The Economics of Number Portability: Switching Costs and Two-part Tariffs." Working Paper, Department of Economics and Center for Research in Network Economics and Communications, University of Auckland, Auckland, New Zealand.

Beggs, A., P. Klemperer, 1992. Multi-period Competition with Switching Costs. Econometrica, 60, 651-666.

Buehler, S., R. Dewenter, J. Haucap. 2006. Mobile Number Portability in Europe. *Telecommunications Policy*, 30, 385 – 399.

Caminal, R., C. Matutes. 1990. Endogenous Switching Costs in a Duopoly Model. *International Journal of Industrial Organization*, 8, 353–373.

Chen, Y. 1997. Paying Customers to Switch. *Journal of Economics and Management Strategy*, 6, 877-897.

Drucker, J. 2003. Cellular Carriers Offer FCC New "Number Portability" Plan. *Wall Street Journal*, April 10.

Federal Communications Commission (FCC). Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services, *Ninth Report- Thirteenth Report*, 2004-2008.

Farrell, J., P. Klemperer. 2007. Coordination and Lock-In: Competition with Switching Costs and Network Effects. *Handbook of Industrial Organization*, 3, 1967–10005.

Farrell, J., C. Shapiro. 1988. Dynamic Competition with Switching Costs. *RAND Journal of Economics*, 19, 123–37.

Fudenberg, D., J. Tirole. 2000. Customer Poaching and Brand Switching. *RAND Journal of Economics*, 31, 634–657.

Gerpott, T. J., W. Rams, A. Schindler. 2001. Customer Retention, Loyalty, and Satisfaction in the German Mobile Cellular Telecommunications Market. *Telecommunications Policy*, 25, 249-269.

Grayson, N. 2008. Loyalty Report Provides a Look into the Future of the Wireless Industry. Walker Information.

Grajek, M., T. Kretschmer. 2009. Usage and Diffusion of Cellular Telephony, 1998-2004. *International Journal of Industrial Organization*, 27, 238-249.

Gruber, H. 1999. An Investment View of Mobile Telecommunications in the European Union. *Telecommunications Policy*, 23, 521-538.

Hahn, J. 2003. Nonlinear Pricing of Telecommunications with Call and Network Externalities. *International Journal of Industrial Organization*, 21, 949-967.

Hausman, J. 1978. Specification Tests in Econometrics. *Econometrica*, 46, 1251-1271.

Hausman, J. 1997. Valuing the Effect of Regulation on New Services in Telecommunications. *Brookings Papers on Economic Activity: Microeconomics.* 1997, 1-38.

Hazlett, T.W., R.E. Munoz. 2009. A Welfare Analysis of Spectrum Allocation Policies. *RAND Journal of Economics*, 40, 424–454.

Kim, H., S. Byun, M. Park. 2004. Mobile Handset Subsidy Policy in Korea: Historical Analysis and Evaluation. *Telecommunications Policy*, 28, 23–42.

Klemperer, P. 1987a. Markets with Consumer Switching Costs. *Quarterly Journal of Economics*, 102, 375–394.

Klemperer, P. 1987b. The Competitiveness of Markets with Switching Costs. *RAND Journal of Economics*, 18, 138–150.

Klemperer, P. 1989. Price Wars Caused by Switching Costs. *Review of Economic Studies*, 56, 405–420.

Laffont, J., P. Rey, J. Tirole. 1998. Network Competition: II. Price Discrimination. *RAND Journal of Economics*, 29, 38–56.

Lee, J., Y. Kim, J. Lee, Y. Park. 2006. Estimating the Extent of Potential Competition in the Korean Mobile Telecommunications Market: Switching Costs and Number Portability. *International Journal of Industrial Organization*, 24, 107–124.

McCloughan, P., S. Lyons. 2006. Accounting for ARPU: New Evidence from International Panel Data. *Telecommunications Policy*, 30, 521–532.

Park, M. 2007. The Economic Impact of Wireless Number Portability. Working paper, Department of Economics, University of Minnesota, Minneapolis, MN.

Parker, P. M., L. Roller. 1997. Collusive Conduct in Duopolies: Multimarket Contact and Cross-ownership in the Mobile Telephone Industry. *RAND Journal of Economics*, 28, 304-322.

Richtel, M. 2003. Cellphone Deals Sweeten in Face of New Rule on Keeping Number. *New York Times*, October 18.

Shaffer, G., Z.J. Zhang. 2000. Pay to Switch or Pay to Stay: Preference-Based Price Discrimination in Markets with Switching Costs. *Journal of Economics and Management Strategy*, 9, 397-424.

Shapiro, C., H. Varian. 1999. *Information Rules: A Strategic Guide to the Network Economy*. Harvard Business School Press.

Shi, M., J. Chiang, B. Rhee. 2006. Price Competition with Reduced Consumer Switching Costs: The Case of "Wireless Number Portability" in the Cellular Phone Industry. *Management Science*, 52, 27-38.

Shin, D. H. 2006. A Study of Mobile Number Portability Effects in the United States. *Telematics and Informatics*, 24, 1–14.

Stango, V. 2002. Pricing with Consumer Switching Costs: Evidence from the Credit Card Market. *Journal of Industrial Economics*, 50, 475–492.

Stole, L. A. 2007. Price Discrimination and Competition. *Handbook of Industrial Organization*, 3, 2223–2286.

Taylor, C. R. 2003. Supplier Surfing: Competition and Customer Behavior in Subscription Markets. *RAND Journal of Economics*, 34, 223–246.

Wareham, J., A. Levy, W. Shi. 2004. Wireless Diffusion and Mobile Computing: Implications for the Digital Divide. *Telecommunications Policy*, 28, 439-457.

Viard, V. B. 2007. Do Switching Costs Make Markets More or Less Competitive? The Case of 800-Number Portability. *RAND Journal of Economics*, 38, 146–163.

This chapter, in full, is co-authored with Kevin Zhu. The dissertation author was the primary author.