Out of the Trap: Conversion Funnel Business Model, Customer Switching Costs, and Industry Profitability

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Abstract

Research summary: Across many industries, firms employ a conversion funnel business model to attract customers with basic and affordable products, generate lock-in, and then sell them more advanced and expensive products. We argue that this business model, coupled with high customer switching costs, results in a market outcome characterized by aggressive pricing and reduced profits. A sudden reduction in customer switching costs disrupts the conversion funnel and can eventually increase industrywide prices and profitability, an outcome that contradicts conventional wisdom in strategy research. We develop a stylized model to formalize our ideas and provide supportive evidence using a difference-in-differences methodology with staggered treatment for a large, global sample of mobile telecommunications operators.

Managerial summary: Industry changes that lower customer frictions can surprisingly be beneficial for companies. Building on the telecommunications industry, we document how a reduction in customer switching costs following mobile number portability increases the profitability of mobile operators. We explain this finding based on a change in companies' business model. When switching costs are high, companies adopt a funnel business model designed to convert customers from basic to advanced products. While advantageous for a single company, when strategic interactions are accounted for, the diffusion of this business model has a depressive effect on average market prices and profitability. A reduction in customer switching costs breaks the funnel and decouples product pricing decisions that, counterintuitively, can lead to higher industrywide prices and greater profitability.

Keywords: Customer Switching Costs, Industry Profitability, Conversion Funnel, Business Model, Market Frictions

1. INTRODUCTION

Extant strategic management (Chatain & Zemsky, 2011; Denrell, Fang, & Winter, 2003; Porter, 1996; Shi, Chiang, & Rhee, 2006) and industrial organization (Beggs & Klemperer, 1992; Klemperer, 1995; Tirole, 1988) literature defines customer switching costs as a source of market power, leading to higher prices and increased firm profits. Switching costs can generate a lock-in effect on customers (Porter, 1985), thus favoring incumbents (Brush, Dangol, & O'Brien, 2012; Gómez & Maícas, 2011; Wei & Zhu, 2018) and reducing rivalry (Mas-Ruiz, Ruiz-Moreno, & Ladrón de Guevara Martínez, 2014). Therefore, reducing customer switching costs should arguably increase competition and reduce firm profits. Such anticipated outcomes lead to efforts to increase online identity and data portability across online platforms as a means to reduce the power of internet giants like Facebook or Google

(Gans, 2018; Geradin & Kuschewsky, 2013). Some of these interventions, designed to reduce customer switching costs, have generated the expected outcomes (Viard, 2007); others, however, have produced unintended consequences (Shi et al., 2006; Wei & Zhu, 2018), as firms can strategically respond to these changes.[2] Surprisingly, little attention in strategy research has focused on how firms respond to changes in customer switching costs, despite the strategic importance of such market friction (Abolfathi, Santamaria, & Williams, 2021; Burnham, Frels, & Mahajan, 2003; Chatain & Zemsky, 2011; Mahoney & Qian, 2013). In this paper, we develop a game-theoretic model to show how firms modify their business models and adapt their pricing strategies in reaction to an exogenous reduction in customer switching costs and test its empirical predictions in the global mobile telecommunications industry. Contrary to conventional wisdom in strategy research, our findings show that a reduction in customer switching costs has a positive effect on firms' average price and profitability.

Our model builds on the notion that, in the presence of significant customer switching costs, firms develop business models that resemble funnels, designed to convert customers of a basic and inexpensive version of a product into adopters of an advanced and more profitable version. Firms enjoy market power with their advanced version due to customer switching costs, yet they also compete more aggressively with their basic version because they take into account the rents from the conversion of customers to the advanced version. Put differently, by creating a link between the pricing of the two versions, a conversion funnel business model shifts the locus of competition toward the basic version market. The removal of customer switching costs can be beneficial for firms as it breaks the conversion

[2] Viard (2007) finds that the portability of 800-numbers reduced prices for toll-free telephone services. In contrast, Shi et al. (2006) provide evidence that wireless number portability led to discriminatory pricing schemes by large firms, which increased market concentration. Similarly, Wei and Zhu (2018) show that larger firms were able to exercise market power and keep prices high even after a reduction of customer switching costs.

funnel logic and redistributes competition between the two versions. Our model shows that average prices and profits increase after the removal of customer switching costs if the advanced version market is more differentiated than the basic version market.

The mobile telecommunications industry constitutes an attractive context to test our model predictions. Most large mobile telecommunications firms have both prepaid and postpaid service subscribers (Banker, Chang, & Majumdar, 1998; Shi, Li, & Bigdeli, 2016). Prepaid services are relatively affordable and suitable for cost-conscious customers who want to try out the mobile plan; postpaid services tend to be more expensive and address customer needs as they evolve over time and as customers become more experienced users (Gruber, 2005). Firms typically offer prepaid services to attract new customers and then seek to generate lock-in effects, with the ultimate goal of converting customers to more profitable postpaid services. This process reflects a conversion funnel business model. In the late 1990s, countries around the world started implementing mobile number portability (MNP) policies that have enabled customers to switch their service providers while keeping their contact numbers, thereby substantially reducing switching costs. We explore how pricing strategies and profits have changed in the aftermath of MNP policy.

We collect data on mobile telecommunications operators worldwide from 2000 to 2017. Because the implementation of MNP was staggered across countries, we can apply a difference-in-differences approach. The results are consistent with our predictions. After the implementation of MNP, the price of prepaid services increased, while the price of postpaid services barely changed. Moreover, the increase in the prepaid service price prompted a shift toward purchases of postpaid services. The resulting change in customer composition (more customers buying postpaid services) and the price increase in the prepaid segment increased firms' profits. Furthermore, the effect of removing customer switching costs on prices is stronger in concentrated advanced version markets where firms have high market power (arguably due to high differentiation). Various robustness checks confirm and establish the theorized mechanism.

In turn, we make two primary contributions. First, we provide new insights into the strategies firms adopt in the face of market frictions (Abolfathi et al., 2021; Burnham et al., 2003; Chatain & Zemsky, 2011; Mahoney & Qian, 2013; Mawdsley & Somaya, 2018). Although several studies have shown how customer switching costs help improve firm performance by creating market power over locked-in customers (Brush et al., 2012; Gómez & Maícas, 2011; Mas-Ruiz et al., 2014), we suggest that when strategic interactions are accounted for, the picture becomes more complex. We show how firms' business models interact in nontrivial ways with changes in customer switching costs to determine firms' pricing strategies and profitability, which can increase when market frictions are removed. Our attention to business models (Amit & Zott, 2001; Teece, 2010; Zott & Amit, 2008) suggests a new contingency through which firm profitability increases when rivalry restraints diminish (Makadok, 2010, 2011). Our findings can likely be extended to other industries in which firms adopt a funnel business model to attract new customers by offering an affordable basic version of a product in the hope that a significant fraction of these customers subsequently shifts to a more advanced and expensive version.

Second, we contribute to studies on competition through business models (Casadesus-Masanell & Zhu, 2010, 2013), highlighting how the presence of market frictions can force firms to adopt pricing strategies that harm profitability. Doing so, we build on the notion of "Bertrand supertraps" (Cabral, 2016; Cabral & Villas-Boas, 2005; Lam, 2017), whereby intrafirm product interaction makes otherwise positive shocks to firms' profit functions (e.g., an increase in economies of scope or customer switching costs) detrimental to performance. We add new insights to the literature by considering the business models of competing firms as a specific form of intrafirm product interactions that might combine with other market-side characteristics, such as customer switching costs, to create a Bertrand supertrap. In addition, we provide empirical evidence to corroborate these theoretical conjectures.

2. THE CONVERSION FUNNEL AS A BUSINESS MODEL

A business model reflects how "the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit" (Teece, 2010: 172). The pervasiveness of the internet and formation of new information technology–based businesses in the 1990s (Amit & Zott, 2001; Shafer, Smith, & Linder, 2005) prompted an increase in theoretical research to define and classify business models (Zott, Amit, & Massa, 2011) and study their fit with underlying market characteristics (Priem, Wenzel, & Koch, 2018). Market frictions (e.g., customer switching costs) that frequently emerge from transactions between buyers and firms (Chatain & Zemsky, 2011; Mawdsley & Somaya, 2018) represent important contingencies that can guide firms' strategic decisions (Mahoney & Qian, 2013) and shape their value creation and value capture mechanisms and, thus, their business model.

We investigate the conversion funnel as a particular type of business model in which firms offer a basic version and an advanced version of a product simultaneously. The basic version is a relatively inexpensive variation, with limited features, suitable for budget-constrained customers. The advanced version has more features and appeals to customers as their needs evolve over time. A conversion funnel business model relies on the basic version as a way to attract new customers, whom the firm hopes to lock in and then encourage to upgrade their interaction by purchasing the more profitable, advanced version. As documented in previous studies, this type of cross-selling strategy is more effective in the presence of high customer switching costs (Abolfathi et al., 2021; Brush et al., 2012).[3] Consider file-hosting services as an example. Providers in this market (e.g., Dropbox, Google

[3] Abolfathi et al. (2021) find that the reduction in customer switching costs in the telecommunications industry triggered a process of specialization in which focused firms (mostly prepaid) increased their market share, thereby reducing the industry adoption of the conversion funnel business model.

Drive) offer a basic version, at a lower price, that grants users access to a limited amount of space and personal assistance and a premium version, at a higher price, that gives customers unlimited space and a host of additional services. Customers often try the service without the intention of making a strong commitment by purchasing the basic version. They may later upgrade to the premium version if they find the service appealing and as their needs evolve. When this happens, customer switching costs (e.g., wasting time and risking the loss of files if they transfer to another provider) help keep customers who start with the basic version from switching to another provider. The conversion funnel business model is widespread and also entails those types of business models labeled as freemium (free basic version and paid premium version) (Arora, Ter Hofstede, & Mahajan, 2017; Rietveld, 2018). Basic versions of products aimed at attracting customers who might later migrate to more advanced versions and remain loyal to the brand are present in industries such as software, mobile applications, telecommunications, cable TV, and automobiles, among others.

3. A SIMPLE MODEL OF CONVERSION FUNNEL AND CUSTOMER SWITCHING COSTS

Before delving into the model, we preview the basic economic intuition behind its main findings. Customers enter the market by purchasing the basic version of a product and later develop a preference for the advanced version. In the presence of high switching costs, customers are bound to buy the advanced version from the same firm that sold them the basic version. This implies that there is no interfirm competition on the advanced version and firms can charge a higher price to captive customers. However, high customer switching costs make competition tougher on the basic version by creating a link between the pricing of the two versions. Because the marginal revenue of a new customer buying the basic version also includes the expected rent from the conversion to the advanced version, pricing becomes more aggressive in the basic version market. Put differently, while high customer switching costs increase value capture in the advanced version market, they also shift the competitive battleground to the basic version market through the anticipation effect. This is especially damaging for firms' profits when the basic version market is less (horizontally) differentiated than the advanced version market. Counterintuitively, if this latter condition holds, the removal of customer switching costs is beneficial for firms because it redistributes competition between the two versions.

3.1. Model assumptions

We build on the standard Hotelling model, which has been widely used to analyze price competition with customer switching costs (see, for a review, Villas-Boas, 2015). Each of two horizontally differentiated firms, *i* and *j*, provides two vertically differentiated versions—basic and advanced—of a product to customers for two periods, t_1 and t_2. Customers are uniformly distributed on the [0, 1] interval, and the two firms are located at the extremes. The position of a customer on the segment identifies the distance of firms *i* and *j* from the customer's ideal preference for the underlying characteristics of the products. Customers incur linear transportation costs, T_b (basic version) and T_a (advanced version), if they want to purchase from a firm that is "distant" from their ideal preferences. The mass of customers is standardized to 1. We assume that customers' preferences do not change across periods (Klemperer, 1995) and are the same for the basic and advanced versions.[4] This is, for instance, the case when the advanced version has the same underlying characteristics as the basic version, although of a higher quality.

Customers only value the basic version in t_1, while they develop a taste for the advanced version in t_2.[5] Their willingness to pay is u for the basic version and $U > u$ for the

[4] Alternatively, one could assume that customers' preferences change (i.e., they are different and independent) across periods (e.g., Cabral & Villas-Boas, 2005). Results hold qualitatively unchanged with either assumption (see Appendix 1).

[5] This is just a simplification, and the insights hold unchanged if one assumes that only a fraction of the customers develops a taste for the advanced version in the second period.

advanced version. Firms compete on price such that they choose a price for the basic version in t_1 (p_b) and cannot change it later. Then, they choose the price of the advanced version in t_2 (p_a). The advanced version is only offered in t_2, whereas the basic version is offered in both periods. A customer who has purchased the basic version of firm *i* in period t_1 will go through the conversion funnel in t_2 if the indirect utility from buying the advanced version of firm *i* is higher than both the indirect utility from continuing with the basic version of firm *i* and the indirect utility of switching to the advanced version of firm j.[6]

We introduce some additional assumptions to simplify the exposition. Specifically, we assume that firms have symmetric zero marginal costs for the basic version and symmetric constant marginal costs $c > 0$ for the advanced version. The parameters capturing the willingness to pay, u and U, are high enough that both markets are fully served in the equilibrium without switching costs. We also assume that at prices equal to marginal costs, any customer in the segment prefers the advanced version to the basic version (mathematically: $U - u - c \geq T_a - T_b$), which is equivalent to saying that the advanced version is a vertical improvement (e.g., higher quality) over the basic version. Finally, we assume that customers are fully forward looking when they make consumption decisions.

In the baseline model, the only decision variables for firms are the prices of the basic and advanced versions. All other parameters are assumed to be exogenous. In the extensions, we discuss how findings change when the quality of the advanced version (U) can be chosen by firms, while in Appendix 1 we provide formal proofs.

3.2. Competition with (and without) customer switching costs

[6] The indirect utility is equal to the willingness to pay minus the transportation costs, minus the price, and minus the switching costs for changing firms.

To begin, we assume that switching costs are high enough that it is never optimal for customers to switch firms (Klemperer, 1995).[7] Thus, all customers who buy from firm *i* in t_1 buy from firm *i* in t_2, selecting either the basic or the advanced version. We solve the model by backward induction starting from period t_2. With high switching costs, firms are monopolists for customers who want the advanced version and have acquired the basic versions in t_1. Given p_{bi}, firm *i* chooses p_{ai} to maximize profits in t_2. Our first lemma defines the optimal price for the advanced version:

Lemma 1. Advanced version price: *With high switching costs,* $p_{ai}^* = p_{bi} + \Delta$ *, where* $\Delta = (U-u) - x_b(T_a - T_b) > 0$ *and* x_b *is the indifferent basic version customer in* t_1.

<u>Proof</u>: See Appendix 1.

Thus, the price of the advanced version is equal to the price of the basic version, p_{bi}, plus a markup, Δ. This markup is capped by intrafirm competition between versions; that is, if the firm charges a too high price for the advanced version, customers will not switch to it. Next, in t_1, firms choose the price of the basic version. The profit function of firm *i* is

$$\pi_i = x_b p_{bi} + x_b(p_{ai}^* - c).$$

Lemma 2 summarizes the equilibrium prices in both periods.

Lemma 2. **Equilibrium prices:** *With high customer switching costs,*

$$p_b{}^*(sc) = T_b - \frac{[(U-u)-c-(T_a-T_b)]}{2} < T_b \text{ , and } p_a{}^*(sc) = T_b + \frac{[(U-u)+c)]}{2} .$$

<u>Proof</u>: See Appendix 1.

The intuition behind Lemma 2 is simple: Firms compete aggressively with the basic version, but they have a captive market in the advanced version in t_2. Anticipating the extra profits they will be able to make in t_2, firms become more aggressive in their efforts to attract customers with the basic version and charge a low price (lower than the equilibrium price

[7] A sufficient condition is that customer switching costs (*s*) are higher than the difference in willingness to pay between the two versions ($U - u$).

without switching costs). Notice that $[(U - u) - c - (T_a - T_b)] > 0$ because the advanced version is a vertical improvement (e.g., higher quality) over the basic version. This mechanism underlies a conversion funnel business model, and the result is akin to the logic of Bertrand supertraps (Cabral & Villas-Boas, 2005).

Consider now the case in which customer switching costs are null. Pricing decisions in each period are independent, and prices are determined by the standard Hotelling static equilibrium. Firms charge ${p_b}^*(nsc) = T_b$ and ${p_a}^*(nsc) = T_a + c$. Comparing these prices with the equilibrium prices when switching costs are high, we conclude:

Proposition 1a: *The removal of customer switching costs breaks firms' conversion funnel, leading to (i) an increase in the equilibrium price of the basic version and (ii) a reduction in the equilibrium price of the advanced version if and only if $U - u - c \geq 2(T_a - T_b)$.*

Proof: See Appendix 1.

To further elaborate on Proposition 1a, a reduction in the equilibrium price of the advanced version following the removal of customer switching costs happens when the difference in the value created between the advanced and the basic version $(U - c - u)$ is large, which relaxes the cap on the price of the advanced version (see Lemma 1) in the case of high customer switching costs.

Next, we compute the average market price over the two periods, i.e., $Avg\ p^* = {p_b}^* + {p_a}^*$. Comparing the average market price in the high-switching-cost scenario with that in the null-switching-cost scenario, we conclude the following:

Proposition 1b: *The removal of customer switching costs results in an increase in the average market price if horizontal differentiation in the advanced version is higher than horizontal differentiation in the basic version ($T_a > T_b$).*

Proof: See Appendix 1.

The intuition behind this proposition is that customer switching costs, by encouraging the adoption of a conversion funnel business model, have the side effect of shifting the locus of competition upfront in the basic version market. The removal of switching costs breaks the funnel and makes competition more evenly distributed between the two versions. This effect is beneficial for firms if they enjoy higher (horizontal) differentiation in the advanced version market than in the basic version market.

Finally, higher market prices translate into higher profits for firms. Formally stated:

Proposition 1c: *The increase in the average market price results in an increase in firm profitability.*

In our stylized model with symmetric constant marginal costs, an increase in the average price always translates into higher profits for firms. However, this equivalence might not hold in the presence of more complex cost structures.

3.3. Customer switching costs and share of the advanced version

In the basic version of the model, we have assumed that all customers display the same willingness to pay for the advanced version in t_2, which implies that, in equilibrium, they all buy the advanced version both with high customer switching costs and when switching costs are removed. We now relax this assumption to study how the removal of customer switching costs and the associated change in pricing strategies can also affect the share of customers purchasing the advanced version.

Assume that all customers value the advanced version in t_2, but to different degrees. A share $\delta < 1$ of customers displays a high willingness to pay U for the advanced version and a share $(1 - \delta)$ has a lower willingness to pay $\hat{u}$, such that $u < \hat{u} < U$. In other words, while in t_2 all customers value the advanced version more than the basic version, some customers show a higher willingness to pay than others.

We start with the scenario with high customer switching costs:

Lemma 3: *With high customer switching costs, there exists an equilibrium solution in which only δ customers buy the advanced version in period t_2. The parameter space in which this solution occurs expands as U and δ increase and $\hat{u}$ decreases.*

Proof: See Appendix 1.

The explanation for Lemma 3 is simple: With high customer switching costs, firms are monopolists in the advanced version market. Thus, they have the choice of allowing only customers with a high valuation to buy the advanced version for a high price or allowing everyone to buy the advanced version for a relatively lower price.[8] The former option is preferred when the willingness to pay of those customers who like the advanced version the most (U) is high while the willingness to pay of those who like it just a little ($\hat{u}$) is low and the share of customers with a high valuation (δ) is high.

In the scenario in which there are no switching costs, in equilibrium, all customers buy the advanced version in t_2. Comparing the share of customers purchasing the advanced version in the scenario with high switching costs (see Lemma 3) with the share of customers purchasing the advanced version in the scenario with no switching costs (all customers), we derive the following proposition:

Proposition 2: *The removal of customer switching costs results in a larger proportion of customers buying the advanced version of the product.*

3.4. Additional implications and extensions of the model

Proposition 1b predicts that the removal of customer switching costs increases the average market price if horizontal differentiation in the advanced version is higher than horizontal differentiation in the basic version (i.e., $T_a > T_b$). This condition suggests that the degree of (horizontal) product differentiation in the advanced version market (T_a) is an important

[8] Although the algebra is more complex, the same intuition applies with a continuous downsloping demand function for the advanced version: Lowering the price of the advanced version attracts more customers at the expense of a lower margin.

moderator of the price increase. Comparing the equilibrium prices derived in our model, it is easy to see that $\frac{\partial(p_{avg}(nsc)-p_{avg}(sc))}{\partial T_a} > 0$, i.e., the more (horizontally) differentiated the advanced market is, the greater the increase in the average market price due to the removal of customer switching costs. This result is in line with the core theoretical intuition of our model. As we anticipated, the removal of switching costs breaks the conversion funnel and redistributes competition between the two versions. This effect is more beneficial for firms if they enjoy high (horizontal) differentiation in the advanced version market because they can still exert a certain degree of market power and thus charge higher prices.

Due to expositional convenience, we assume that customer switching costs are initially very high and analyze what happens to the price once they are completely removed. In the model extension in Appendix 1, we show that the main insights hold if customer switching costs are relatively small and parametrized in the customer utility function. Results also hold unchanged if we assume customers are myopic, i.e., they maximize their utility period by period. Myopic customers do not anticipate that they will be charged a higher price for the advanced version when they acquire the basic version and thus will be less responsive to price differences. In some variations of our model, having myopic customers implies that our results are even stronger. The key findings also hold when we assume that the location of customers on the segment changes between periods as in Cabral and Villas-Boas (2005).

Finally, we have explored the validity of our findings when the set of choice variables available to firms in the model expands. An important dimension that firms can influence is product quality. In Appendix 1, we report a simple extension of our baseline model in which firms can invest in quality to increase customers' willingness to pay for the advanced version (*U*). When quality is modeled as a choice variable, we find that the removal of customer switching costs produces even stronger effects on prices and firm profitability compared to when quality is exogenous.

4. EMPIRICAL CONTEXT AND ANALYSIS

The global mobile telecommunications industry provides the empirical context for this research. We focus on the industry from 2000Q1 to 2017Q1, during which MNP policies were implemented in many countries throughout the world. Our final sample, after removing firms with missing pricing data, includes 563 national telecommunications operators (which own network infrastructure and license by purchasing radio spectra from regulators), of which 337 experienced an MNP policy and 226 did not, across 178 countries (for the list of countries, see Table A1 in Appendix 2). Overall, we have 26,976 firm-quarter observations. The data source for all firm- and country-level variables is the GSMA Intelligence database.

We select the mobile telecommunications industry because it has several attractive features for our research. The most important feature is the presence of an exogenous shock affecting customer switching costs that resulted from the introduction of MNP. First introduced in Singapore in 1997, MNP is an effort to enhance competition in the industry and reduce prices for mobile telecommunications (Bühler, Dewenter, & Haucap, 2006). Before MNP, subscribers had to give up their numbers when switching providers. MNP enabled customers to switch service providers while keeping their contact numbers, thus introducing an exogenous reduction in customer switching costs. A review of industry literature shows that firms had little to no influence over the timing of MNP implementation. Qualitative evidence reveals, for example, that factors such as a country’s political priorities or technological readiness were the main drivers of MNP’s staggered implementation (Bühler et al., 2006).

Some empirical efforts seek to examine the exogeneity assumption of MNP implementation. Wei and Zhu (2018) find that the relationship between MNP and market concentration at the global level is similar to that in a subsample of firms in countries where MNP is mandated by a supranational organization (European Union) and thus is more likely exogenous. It is also worth noting that although MNP adoption is a form of market liberalization, it did not tend to be implemented as part of a larger package, which might confound the results of the analysis (Abolfathi et al., 2021). We provide additional tests of any potential indirect effect of the policy in a separate section.

The second attractive feature of the industry is the business model that firms adopt. According to industry literature (Banker et al., 1998; Shi et al., 2016), firms offer two main categories of service: a basic version that is prepaid and an advanced version that is postpaid. As we noted previously, prepaid services appeal to cost-conscious customers who are interested in affordable offers with limited options, and postpaid services work better for more sophisticated customers who are heavy users (Eggers, Grajek, & Kretschmer, 2020; Grajek & Kretschmer, 2009). By offering both services, firms create a conversion funnel in which customers start with prepaid services and then progressively convert to advanced postpaid services as their needs evolve (Abolfathi et al., 2021).

Anecdotal evidence from industry literature supports the idea that the prepaid market is “a way to cater to consumers who are reluctant to sign long-term service contracts” (Russolillo, 2011). As the former executive vice president and chief financial officer of Verizon Communications has indicated, “History shows that when a prepaid customer becomes a postpaid subscriber their usage and revenue increase over time. So it [migration] is not bad and I think that is good for the industry overall” (Verizon Communications, 2014). Telefonica Germany and T-Mobile, among many other firms, have reported considerable growth and profitability due to ongoing customer migration from prepaid to postpaid in German and U.S. markets, respectively (Cheng, 2015; Telefonica Germany, 2020). The conversion funnel business model is especially popular in developing markets, as customers are budget constrained and are likely to start their relationship with telecommunications operators by first purchasing prepaid services. For example, the chief marketing officer of

Digi Telecommunications, a large Malaysian mobile service provider, anticipated that the firm would "continue to drive service revenue growth through prepaid to postpaid conversion" (Inn, 2019).

The mobile telecommunications industry has other attractive features that make it the ideal context to test our theory. Telecommunications markets are oligopolies in which the type of strategic behavior predicted by game-theoretic models is more likely to occur. Finally, the reduction in customer switching costs due to MNP affects simultaneously all firms located in the same country market.

4.1. Measures

4.1.1. Dependent variables: Average prices, profits, and share of postpaid subscribers

A standard proxy of the firm's average service price is the average revenue per user (*ARPU*) (Gómez & Maícas, 2011; Maicas, Polo, & Sese, 2009).[9] *ARPU* refers to the total recurring revenue per user per month. This variable is averaged for a given quarter because GSMA Intelligence reports all the variables at the quarterly level. For the prices of basic and advanced versions (Proposition 1a), we define *ARPU Prepaid* and *ARPU Postpaid* to capture the firm's average price per user in the prepaid (basic) and postpaid (advanced) plans in a given quarter. In addition, we use *ARPU* to proxy for the average market price (Proposition 1b). To avoid skewness, we compute the natural logarithm of these variables. Next, we construct earnings before interest and taxes (*EBIT*) to capture firm profits in a given quarter and test Proposition 1c. This measure is calculated as the firm's total operating profit in a given quarter, before interest and tax, excluding any profit or loss on the disposal of fixed assets and exceptional items, and is reported in billions for facilitating the reporting. We also construct *EBIT*(log) (i.e., the natural logarithm of *EBIT* after a transformation to avoid

[9] There is substantial heterogeneity in mobile plans; consequently, service prices are determined by nonlinear tariffs based on a mix of calls, data packages, and text messages. *ARPU*, according to both industry scholars and practitioners, is the best available measure to account for prices of different plans (McCloughan & Lyons, 2006; Niculescu, Shin, & Whang, 2012).

nonpositive numbers; see, e.g., Eisenmann, 2006). Finally, to test Proposition 2, we use *Postpaid* to capture the proportion of a firm's postpaid subscribers relative to its total subscribers in a given quarter; this value ranges between 0 and 1.

4.1.2. Independent variable: Reduction in customer switching costs

With *PostMNP*, we capture the introduction of the MNP policy in a given country. This variable is equal to 1 for observations in the quarters after the policy introduction in the focal country and 0 for observations before the policy introduction.

4.1.3. Controls

We control for several country-level variables. To capture market concentration and the market power of firms at the country level, we employ a Herfindahl-Hirschman index (*HHI*) divided by 1,000 (thus the regression coefficient captures the effect of a 1,000-point increase in HHI). This index is constructed based on firms' market share in a given country in quarter *t*. We also proxy for business cycles using gross domestic product (*GDP*) in quarter *t* in trillions for ease of reporting. In addition, we account for the stage of adoption of cellular services by country, according to market penetration (*Penetration*), calculated as the total number of subscribers in a given country divided by the population in quarter *t*. Finally, we control for firm and quarterly time fixed effects.[10]

Table 1 contains descriptive statistics. Notably, the average share of postpaid services is much lower than the average share of prepaid services (average *Postpaid* = 0.272). Table 2 displays the correlations among the variables; they are highest among average prices and profits (*ARPU* and *EBIT* measures) and between *Penetration* and *PostMNP*, as we would have expected.

--- Insert Tables 1 and 2 Here ---

[10] Quarterly time fixed effects characterize each year-quarter combination (e.g., treating 2000Q1 and 2001Q1 as different quarters).

4.2. Nonparametric analysis

We start our analysis by visually comparing industry patterns in average price and demand for service versions among treatment and control groups of firms before and after the introduction of MNP, respectively. To draw these figures, we construct treatment and control groups as follows. The treatment group consists of firms located in countries that implemented MNP; the control group consists of a subsample of firms with similar *ARPU* that are tracked exactly during the same years as the firms in the treatment group but located in countries that had not implemented MNP at that time. For example, if a firm in the treatment group adopts MNP in t = 2010Q1, we include another firm in the control group with similar *ARPU* levels that is located in a country that has not adopted MNP, tracking both for the same time window (8 quarters before and after t = 2010Q1).[11]

Figure 1 provides a visual illustration of the comparative MNP effect on average price, measured by *ARPU*(log) of telecommunications services, for the treatment and control groups. The figure reveals a similar *ARPU* pre-trend across the two groups of treatment and control. However, as our theory anticipates, we observe a notable increase in the *ARPU* of treated firms in countries that implemented MNP relative to firms in the control group located in countries that did not implement MNP. A *t*-test confirms that the price difference between treatment and control firms in the figure becomes statistically significant only after the policy change (see Appendix 2, Table A2).

Figure 2 provides a visual representation of the effect of MNP on the share of postpaid subscribers relative to total subscribers (postpaid subscribers %). The control group here is the same as that depicted in Figure 1. We find a remarkable increase in the share of postpaid subscribers of treated firms located in countries that have implemented MNP, in sharp

[11] This selection is necessary to plot comparable firms and time windows in the figures because we cannot control for firm and time fixed effects.

contrast with the share of postpaid subscribers in the control group that did not experience MNP. The pre-trends between the two groups are similar, although the share of postpaid subscribers is slightly higher in the treatment group than in the control group.

--- Insert Figures 1 and 2 Here ---

4.3. Parametric specifications

We use a difference-in-differences methodology with staggered treatment (Bertrand & Mullainathan, 2003; Castellaneta, Conti, & Kacperczyk, 2020) to regress the effect of the introduction of MNP on firm prices and profitability. Due to the staggered implementation, the composition of the group of firms subject to the policy and the control group change over time. For our main analysis, we consider all countries and firms available in the data set, irrespective of their MNP adoption. Therefore, the control group consists of firms located in countries that never implemented MNP, as well as those in countries that have yet to adopt the policy. We also replicate our analysis focusing only on countries that eventually adopted MNP (and exclude those that never adopted) to address any concerns related to the presence of unobserved heterogeneity between adopting and nonadopting countries; the results are qualitatively similar.[12]

The regression model used to test our propositions with firm and time fixed effects is as follows:

$$Dependent\ variable_{it} = \beta_0 + \beta_1 PostMNP_{it} + \bar{\theta} Controls_{it} + \varepsilon_{it}.$$

In this model, *i* indexes the firm, and *t* refers to time. Depending on the proposition being tested, we plug our measures into $Dependent\ variable_{it}$. That is, we use *ARPU* measures (*ARPU Prepaid*, *ARPU Postpaid*, *ARPU*) to test Propositions 1a and 1b, *EBIT* measures to test Proposition 1c, and *Postpaid* share to test Proposition 2. Across the models, the

[12] The results are not reported in the paper but available on request.

coefficient of interest is β_1, which measures the effects of the MNP policy on dependent variables after versus before the regulatory change.

4.4. Main findings

We now unpack the mechanisms underlying increased prices in the industry by looking at the pricing strategies of firms selling both prepaid and postpaid services. For this reason, we first focus our analysis only on firms offering both versions. Then we examine how changes in pricing strategies of firms following MNP affect industrywide profitability. We employ ordinary least squares (OLS) regressions with firm fixed effects and report the results in Table 3. In Model 1, we estimate the effects of MNP on *ARPU Prepaid.* The results reveal the expected positive effect (β = 0.116, p = 0.024) and are consistent in Model 2 after introducing the control variables; MNP increased *ARPU Prepaid* by 16% (p = 0.001). In Model 3, we test the effect of MNP on *ARPU Postpaid* and find no effect (β= 0.028, p = 0.511). The results are similar in Model 4 after introducing the control variables. In accordance with Proposition 1a, firms appear to have reacted to the disruption of the conversion funnel by giving up their aggressive pricing strategy and making the basic prepaid service relatively more expensive. Models 5–6 investigate the effect of MNP on the average price, revealing that MNP had a positive, significant effect on *ARPU*. In Model 6 with controls, we estimate a 16% increase in the average price (p = 0.002). These findings support Proposition 1b: The combined changes in the prices of prepaid and postpaid services following MNP increased the average market price. Finally, in Models 7–9 we explore the effect of MNP on firm profits, using two dependent variables of *EBIT* and *EBIT*(log). In Model 7, we estimate an increase of 47 million dollars in *EBIT* (β = 0.047, p = 0.025). In Models 8 and 9, we use *EBIT*(log) as the dependent variable and obtain consistent results. These findings confirm Proposition 1c: firm profitability increased following MNP.

--- Insert Table 3 Here ---

Table 4 presents the OLS regression models we use to examine the effect of MNP on the share of a firm's postpaid subscribers. Model 2, which includes controls, suggests that MNP increased the share of postpaid subscribers for a firm by 6% on average (p = 0.000). These results confirm Proposition 2: Firms' pricing strategies following MNP resulted in a relative increase in the share of advanced (postpaid) services.

--- Insert Table 4 Here ---

As discussed in the theory section, the magnitude of the increase in the average price and profitability following a reduction in customer switching costs depends on the level of (horizontal) differentiation between firms in the advanced version market (i.e., parameter T_a). While we are not able to capture this variable directly, we can use firms' market power in the advanced version market (postpaid) as a consequence of differentiation. In location models like Hotelling or Salop, differentiation (i.e., transportation costs) is indeed the main source of market power. Building on this idea, we construct *Postpaid HHI* (*Mean* = 4,647.49, *SD* = 1,737.31; min = 1,456, max = 10,000), which is an index of concentration in the postpaid market that varies between 0 and 10,000. A high *Postpaid HHI* indicates that the advanced version market is a concentrated market where firms have high market power (arguably due to differentiation). *Postpaid HHI* is calculated based on firms' postpaid market shares prior to MNP, which are unaffected by potential changes due to the introduction of the policy. Table 5 reports the results of the interaction between *PostMNP* and *Postpaid HHI* using firm fixed and random effects. To facilitate reporting we divide *Postpaid HHI* by 1,000 so that our coefficient of interest captures the effect of a 1,000-point increase in postpaid HHI. Based on Model 1, we estimate a positive interaction effect (β = 0.080, p = 0.002) and a weak negative direct effect of MNP on *ARPU* (β = –0.156, p = 0.186). The turning point is at *Postpaid HHI* = 2,214. These results are in line with our expectations: MNP has a significant, positive effect on *ARPU* only if *Postpaid HHI* is sufficiently high (greater than 2,214), and the effect increases as *Postpaid HHI* grows.

--- Insert Table 5 Here ---

5. ADDITIONAL TESTS

In this section, we rule out alternative explanations for the price increase (the entry of mobile virtual network operators (MVNOs), increases in prepaid quality, and greater industry concentration), examine the importance of conversion funnel in driving our results, and test the robustness of our staggered difference-in-differences analysis by running event-study and stacked regression analyses. All the results of these additional tests are reported in Appendix 2.

5.1. MNP and MVNOs

Although MNP aims to increase competition in a market, it can also facilitate the entry of new, small telecommunications firms such as MVNOs. These small, specialized operators offer relatively affordable mobile services, and they rent network infrastructure and radio spectra from national operators rather than owning them.[13] Prior research suggests that the introduction of MNP had no significant effect on, and is even negatively correlated with, MVNO entry (Riccardi, Ciriani, & Quélin, 2009). Yet, an emergent segmentation pattern due to MVNOs' entry could offer an alternative explanation of our results. In this view, national mobile operators start to focus on the high end of the market (postpaid segment), leading to an increase in their average prices, while MVNOs target cost-conscious subscribers and offer them more affordable services. To rule out this explanation, we collect additional data on the entry rate of MVNOs. We then rerun the regression models testing the effects of MNP on

[13] Our main analysis (and measures) only includes national operators as we do not have access to pricing and sales data for MVNOs. We believe concerns arising from this lack of data are minimized for two reasons: (a) MVNOs are often focused on the low end of the market and hence have a different business model than a conversion funnel and (b) despite variation around the world, MVNOs' subscribers account for a small fraction of total subscribers globally during our study timeline (4% of overall global connections in 2019) (Dehiri & Williams, 2019).

firm pricing strategies while controlling for MVNO entry rate. The results (reported in Table A3) are barely affected by the new controls and still consistent with our main findings.

5.2. MNP and prepaid service quality

An alternative explanation for the increased price of prepaid services might cite enhanced service quality. In response to MNP and increased competition, firms might offer better prepaid packages, which might raise prices. Service quality is a multifaceted concept that is notoriously hard to empirically measure. Nevertheless, we build on the best available "proxies" of service quality in our context. The first measure is *Minutes of Use*. Contrary to postpaid services, prepaid plans have a cap on minutes of talk available. Thus, we can reasonably assume that offering a prepaid plan with more minutes of talk for the same price is a quality improvement for customers. We then estimate whether MNP has an impact on the prepaid plan's *Minutes of Use*. The results, reported in Model 1 Table A4, reveal no impact of MNP on the minutes of use of prepaid plans. Similarly, we test whether MNP has a significant effect on a second proxy for service quality, *Data Usage.* We can again assume that a prepaid plan with more internet data offered at the same price is a quality improvement. We then examine the effect of MNP on *Data Usage* of prepaid plans and find no effect (Model 2, Table A4).

An alternative approach to capture a potential increase in service quality following MNP is to look at investments on the firm side. Improving the quality of telecommunications services generally involves substantial technological and/or infrastructural investments by firms. To proxy for the firm's investments in service quality, we construct two different measures, namely *CAPEX* and *4G Installed Base*. *CAPEX* is a measure of total capital expenditures incurred by the firm to acquire, upgrade, and maintain physical assets such as network equipment and software as well as nonfinancial fixed assets such as brand. We compute the natural logarithm of this measure to reduce its skewness. *4G Installed Base* is a measure of the share of the firm's customers who have access to the latest and fastest network generation, the 4G technology. We test the effect of MNP on these two additional quality measures in Models 3 and 4 of Table A4. The results clearly show that MNP did not have any positive effect on firms' capital expenditures or 4G-installed base. Overall, this set of results suggests that the quality of telecommunications services remained largely unchanged around the time of MNP implementation.

5.3. MNP and market concentration

Rather than increasing competition, MNP might have unintended consequences in terms of market concentration. Wireless number portability in Hong Kong, for instance, resulted in discriminatory pricing patterns and accelerated market concentration rather than helping smaller firms grow (Shi et al., 2006). A similar effect might lead to an increased average service price in our setting. Although we control for market concentration (HHI) in our main regressions, it is worth exploring whether the implementation of MNP correlates with a decrease in competition. Thus, we test the effect of MNP on two market concentration measures: *HHI* and *Number of Firms* (the number of operators in a given country and quarter) in affected countries. The results reported in Table A5 suggest that MNP has only a weak positive effect on *HHI* that is not statistically significant and no effect on the *Number of Firms* in the affected countries.

5.4. The importance of conversion funnel

Firms in our model sell both versions and thus can adopt a conversion funnel business model. The predicted price increase after a reduction in customer switching costs is unlikely to happen when firms specialize in selling just one version. To test the importance of the conversion funnel business model in driving our results, we compare the price increase following MNP in markets in which all firms adopt a funnel business model with other markets in which there are specialized firms too. We thus construct *All Funnel* as a binary variable equal to 1 if all firms in a given country in the pre-MNP period provide both prepaid and postpaid services simultaneously and equal to 0 otherwise. Table A6 presents the regression models testing the interaction effect of *All Funnel* and *PostMNP* on firms' average prices, revealing a positive interaction effect. This finding provides additional support for the mechanism behind the price increase: The adjustment in pricing strategies of firms with *a conversion funnel business model*. In countries in which the conversion funnel business model is not widespread and several firms specialize in selling just one version, MNP has a more ambiguous effect on pricing strategies.

5.5. Event-study regression

We now estimate the effect of MNP on *ARPU* using an event-study difference-in-differences design, which can accommodate the possibility for dynamic treatment effects by including leads and lags of the treatment variable instead of a single binary indicator variable. In addition, such a specification can help us test the presence of any preexisting trends in the average price of firms in countries implementing MNP.[14] Following extant research, we include the full set of relative time indicator variables, excluding only two to avoid multicollinearity (Baker, Larcker, & Wang, 2021). Results, reported in Table A7, show that there is a significant increase in *ARPU* only in years after the introduction of MNP; no significant preexisting trend is observed in the regression. The effect size appears to slightly increase over time, suggesting our treatment effect is not constant over time. Such a possibility demands additional robustness checks, which are discussed in the next section.

5.6. Stacked regression

Recent econometric literature suggests that the standard staggered difference-in-differences design can lead to biased coefficients in the presence of treatment effect heterogeneity (Baker

[14] While Figure 1 provides a good visual representation of similar trends in the average prices between treatment and control groups before MNP, an event-study regression model provides further evidence.

et al., 2021) and/or treatment effects that are not constant over time (Goodman-Bacon, 2021). We follow the stacked regression approach as per Baker et al. (2021) to address any potential bias. As the bias generally arises from the staggered nature of the treatment (Goodman-Bacon, 2021), the stacked regression approach builds on running separate regressions for each different cohort and uses “clean controls” that are not affected by the treatment for the whole estimation window (See Baker et al., 2021 for further details). Thus, we run 14 separate regressions for each cohort of firms adopting MNP between 2001 and 2014, focusing on 4 years before and 4 years after the implementation of MNP. The control group in each regression includes all firms that did not adopt MNP within the –4 and +4 years estimation window. We drop all firms that adopted MNP when our data starts (the year 2000 or before) or when our data ends (2016 and 2017) from our regressions as it is problematic to identify a before/after period for them. We also exclude firms adopting MNP in 2015 due to several missing values. The MNP coefficients of the 14 cohort-specific regressions are reported in Table A8. The coefficients are positive and statistically significant in all regressions except in three, suggesting that our results are quite robust. Finally, we stack all the cohort-specific regressions together to estimate an average effect. The functional specification of this regression is the same as a standard event-study difference-in-differences estimand (as per previous section) except that unit and time fixed effects are saturated with indicators for the specific stacked dataset (Backer et al., 2021). The results, presented in Table A9, are qualitatively similar to our findings in Table A7, except for a more visible downward price trend in all countries before MNP. This trend is consistent with the findings depicted in Figure 1.

6. CONCLUSIONS AND IMPLICATIONS

In this paper, we present some puzzling empirical findings related to the pricing strategy of global telecommunications firms in the wake of mobile number portability (MNP) policy. In response to the policy implementation, an exogenous change that decreased customer switching costs, firms counterintuitively increased their average prices. To explain this puzzle, we propose a game-theoretic model in which firms react to the removal of customer switching costs by transitioning away from an unprofitable industry outcome in which they are trapped. The model shows how, in the presence of significant customer switching costs, firms develop business models that resemble funnels, designed to convert customers of a basic and inexpensive version of a product into adopters of an advanced and more profitable version. However, because firms anticipate the margins they can make on captive customers buying the advanced version they enter into a mutually destructive price battle for the basic version. The removal of customer switching costs can be beneficial for firms as it breaks the conversion funnel logic and redistributes competition between the two versions.

To literature on firm competition with market frictions (Chatain & Zemsky, 2011; Gómez & Maícas, 2011; Mahoney & Qian, 2013; Makadok, 2010; Shi et al., 2006), this study adds the prediction that firms' business models (in our setting, a conversion funnel) interact in nontrivial ways with customer switching costs to determine firms' pricing strategies and profitability. Our paper suggests that strategies aimed at enhancing firm profitability exclusively through creating and maintaining customer frictions are generally not very effective. Indeed, market frictions generate several unexpected side effects on other relevant strategic aspects like resource development (Chatain & Zemsky, 2011) or the ability to exploit competitive advantage (Makadok, 2010). We theoretically and empirically show that customer switching costs, rather than being a source of market power (Porter, 1985), can have a depressive effect on prices and profits. Furthermore, our paper suggests that studying customer switching costs in isolation without considering strategic interactions between firms can lead to faulty conclusions about their consequences.

We also add insights on how business models shape firm competition and profitability under different contingencies (Casadesus-Masanell & Zhu, 2010, 2013). A conversion funnel business model may appear to be beneficial for firms. Yet, there has been a debate on whether this business model (or its derivatives such as the *freemium* model) performs well under rivalry (Arora et al., 2017; Rietveld, 2018; Tidhar & Eisenhardt, 2020). Our theoretical framework and empirical results show that a widespread diffusion of such a business model triggers too much competition (in the basic version segment) and has a negative impact on profits (Cabral, 2016; Cabral & Villas-Boas, 2005). From a regulatory standpoint, our findings suggest the need to better clarify portability policies and their implementation outcomes (Gans, 2018; Geradin & Kuschewsky, 2013; Shi et al., 2006). Government interventions to reduce customer switching costs can lead to drastic changes in firms' business models with unclear effects on social welfare.

This study also raises questions that might be interesting to explore in further research. One of these questions is why the "bad" equilibrium that we characterize in the scenario with high customer switching costs cannot be overcome endogenously by firms. One potential explanation is coordination failure. If one firm alone removes switching costs, a competitor's best response is to maintain them. Similarly, undertaking other actions such as specializing in selling just one variety of the product (advanced or basic) is not profit-maximizing as long as switching costs are high. For example, no customer would risk buying the advanced version directly when a more flexible option (i.e., start with the basic version and move to the advanced version only if needed) is available. Interestingly, the presence of high customer switching costs in our context acts as a barrier to specialization, an outcome that is consistent with the results of Abolfathi et al. (2021). Another interesting avenue for future research is an extension of the model that distinguishes between new and existing customers and allows firms to strategically adapt their pricing based on this feature. Our theory works better when most customers are new and prefer to start with the basic version of the service. Interestingly, such characteristics are more common within the telecommunications markets in developing countries, which are characterized by a young and growing population as well as a larger share of prepaid customers. The increase in average market prices is indeed larger if we limit the empirical analysis to the developing countries.[15] Finally, further work could explore the theorized mechanism in other industries. The model's insights extend to all contexts in which firms sell basic and advanced versions of a product simultaneously by employing a conversion funnel business model. The empirical challenge would be to find exogenous shifters in customer switching costs to draw causal inference.

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[15] The results are not reported in the paper but available on request.

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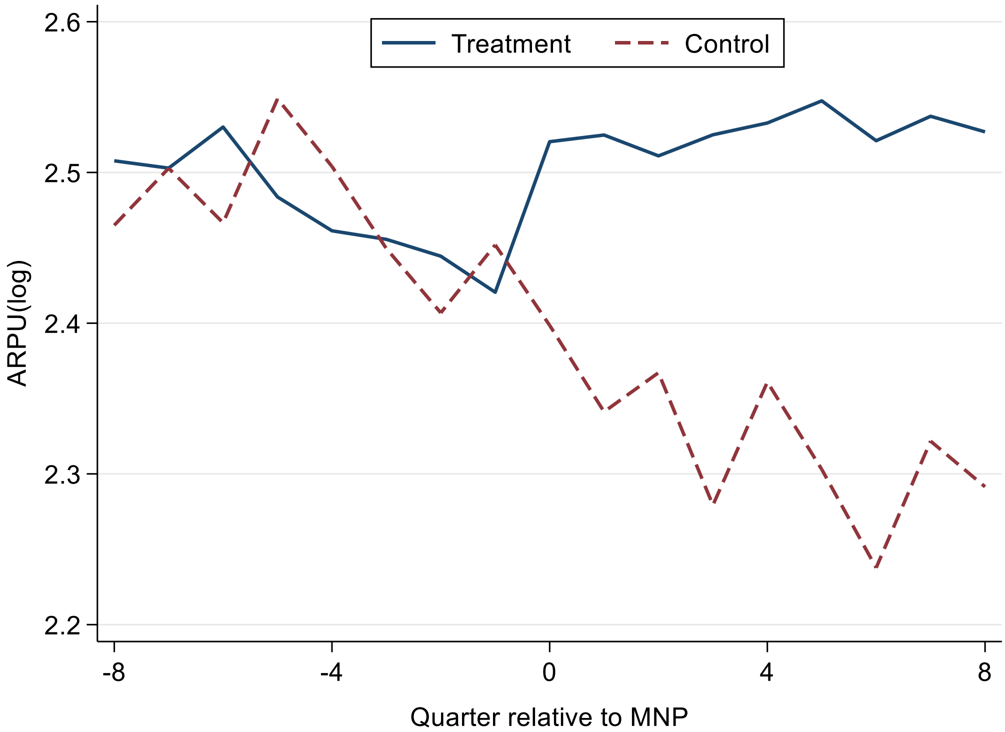
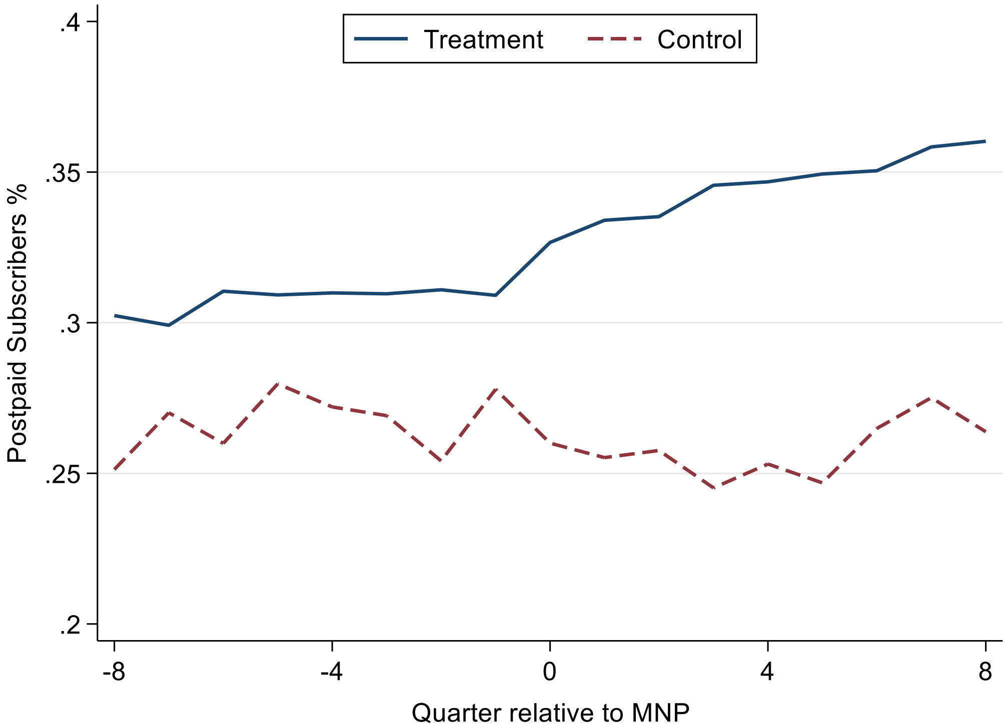
FIGURE 1. MNP introduction and average service price



Notes: The x-axis refers to quarters relative to MNP adoption (firms adopt MNP in different years and quarters).

FIGURE 2. MNP introduction and postpaid subscribers percentage



Notes: The x-axis refers to quarters relative to MNP adoption (firms adopt MNP in different years and quarters).

TABLE 1. Summary statistics

Variables	Notes	Obs.	Mean	SD	Min	Max
Firm level						
ARPU	Dependent variable, average revenue per user	26,976	17.405	17.106	0.018	438.986
ARPU Prepaid	Dependent variable, average revenue per user for prepaid plan	6,542	9.291	6.958	0.333	45.75
ARPU Postpaid	Dependent variable, average revenue per user for postpaid plan	6,542	35.314	26.037	2.265	1,082.931
EBIT	Dependent variable, total operating profit before interest and tax (in billions)	4,123	0.117	0.422	–6.806	5.121
Postpaid	Dependent variable, share of the firm postpaid subscribers to total subscribers	26,976	0.272	0.28	0	1
Country level						
PostMNP	Explanatory variable, binary equal to 1 for quarters after MNP	26,976	0.317	0.465	0	1
HHI	Control variable, Herfindahl-Hirschman index (divided by 1,000)	26,976	4.132	1.819	1.033	10
GDP	Control variable, gross domestic product (in trillions)	26,976	0.696	2.175	0	15.7
Penetration	Control variable, total number of mobile subscribers divided by the population	26,976	0.708	0.476	0	3.006

TABLE 2. Matrix of correlations (*N* = 4,122)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
(1) *ARPU* (log)								
(2) *ARPU Prepaid* (log)	0.883							
(3) *ARPU Postpaid* (log)	0.784	0.811						
(4) *EBIT* (log)	0.201	0.174	0.181					
(5) *Postpaid*	0.705	0.439	0.268	0.144				
(6) *PostMNP*	0.437	0.295	0.207	0.145	0.498			
(7) *HHI*	–0.078	–0.029	0.147	–0.113	–0.269	–0.199		
(8) *GDP*	0.394	0.401	0.260	0.367	0.399	0.274	–0.351	
(9) *Penetration*	0.187	0.085	0.003	0.023	0.259	0.577	–0.069	0.021

TABLE 3. Results of OLS regressions showing changes in firms pricing strategy and profits following MNP

	Proposition 1a				**Proposition 1b**		**Proposition 1c**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)[a]**	**(7)**	**(8)**	**(9)**
Variables	***ARPU Prepaid* (log)**	***ARPU Prepaid* (log)**	***ARPU Postpaid* (log)**	***ARPU Postpaid* (log)**	***ARPU* (log)**	***ARPU* (log)**	***EBIT***	***EBIT* (log)**	***EBIT* (log)**
PostMNP	0.116	0.158	0.028	0.055	0.104	0.161	0.047	0.007	0.006
	(0.024)	(0.001)	(0.511)	(0.184)	(0.059)	(0.002)	(0.025)	(0.021)	(0.032)
HHI		0.037		0.072		0.063			–0.002
		(0.450)		(0.059)		(0.199)			(0.251)
GDP		0.118		0.153		0.106			0.000
		(0.012)		(0.000)		(0.000)			(0.967)
Penetration		–0.382		–0.050		–0.529			0.009
		(0.006)		(0.618)		(0.000)			(0.094)
Constant	2.486	2.394	3.621	3.260	3.233	3.092	0.026	1.921	1.924
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.396)	(0.000)	(0.000)
Observations	6,542	6,542	6,542	6,542	6,542	6,542	4,123	4,122	4,122
R-squared	0.441	0.477	0.492	0.528	0.467	0.545	0.026	0.026	0.028
Number of firms	216	216	216	216	216	216	174	174	174
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm. The results remain similar if we use random effects or error clustering at the country level. Our sample includes those firms that offer *both* prepaid and postpaid services. The sample size in models 7–9 drops to 174 firms due to missing values.

[a] The results are similar when we replicate the regression model using the whole sample with all firms regardless of their business model.

TABLE 4. Results of OLS regressions showing changes in the firm's postpaid share following MNP

Variables	Proposition 2	
	(1)	(2)
	Postpaid	***Postpaid***
PostMNP	0.013	0.066
	(0.107)	(0.000)
HHI		–0.007
		(0.037)
GDP		–0.035
		(0.000)
Penetration		–0.154
		(0.000)
Constant	0.267	0.448
	(0.000)	(0.000)
Observations	26,976	26,976
R-squared	0.002	0.210
Number of firms	563	563
Firm fixed effect	Yes	Yes
Quarterly time fixed effects	Yes	Yes

Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm. The results remain similar if we use random effects or error clustering at the country level.

TABLE 5. Effect of postpaid market concentration on firm average price following MNP

Variables	(1) ***ARPU*(log)**	(2) ***ARPU*(log)**
PostMNP	–0.155	–0.156
	(0.186)	(0.181)
PostMNP× Postpaid HHI	0.078	0.081
	(0.002)	(0.001)
Postpaid HHI		0.047
		(0.079)
HHI	0.050	0.051
	(0.006)	(0.004)
GDP	0.115	0.124
	(0.000)	(0.000)
Penetration	–0.167	–0.122
	(0.063)	(0.162)
Constant	2.773	2.501
	(0.000)	(0.000)
Observations	26,011	26,011
R-squared	0.435	
Number of firms	545	545
Firm fixed effect	YES	−
Firm random effect	−	YES
Quarterly time fixed effects	YES	YES

Notes: OLS regression models. *P*-values are in parentheses. Robust standard errors are clustered by firm and remain consistent with alternative specifications. To facilitate reporting we divide *Postpaid HHI* by 1,000.

APPENDIX 1

Proof of Lemma 1

In t_2, firm *i*'s customers discover that they value the advanced version, from which they derive utility *U*. Depending on p_{ai}, they might buy the advanced version or the basic version offered by firm *i* (they cannot switch to firm *j* for the advanced version because of high switching costs). In t_2, firms take the price and demand of the basic version as given. x_b identifies the location of the farthest customer on the segment that has acquired the basic version from firm *i*. The highest p_{ai}, such that all captive customers of firm *i* buy the advanced version, is $p^*_{ai} = p_{bi} + \Delta$, where $\Delta = (U - u) - x_b(T_a - T_b)$. It is not profitable for firm *i* to set a price for the advanced version that is below p^*_{ai} since demand does not change. Conversely, we can now show that any price above p^*_{ai} does not maximize profits. Suppose that the optimal price for the advanced version is $\widehat{p_{ai}} > p_{bi} + \Delta$. A customer who is indifferent with respect to buying the advanced version or buying the basic version is then defined by $\frac{(U-u)-(p_{ai}-p_{bi})}{T_a - T_b} < x_b$. In this case, firm *i* chooses p_{ai} to maximize:

$$\frac{(U-u)-(p_{ai}-p_{bi})}{T_a-T_b}(p_{ai}-c) + \left[x_b - \frac{(U-u)-(p_{ai}-p_{bi})}{T_a-T_b}\right]p_{bi}.$$

After taking the first-order condition, $\widehat{p_{ai}} = p_{bi} + \frac{(U-u)-c}{2}$. Note that $p^*_{ai} > \widehat{p_{ai}}$ if $(U-u) - c \geq 2x_b(T_a - T_b)$. This latter condition is always verified in a symmetric equilibrium as long as $U - u - c \geq (T_a - T_b)$. Indeed, in a symmetric equilibrium, firms evenly split their market share, implying that x_b cannot be larger than ½.

Proof of Lemma 2

Forward-looking customers anticipate that they will value the advanced version in t_2 and will have to pay the corresponding price. Thus, in t_1 their choice between firm *i* and firm *j* fully accounts for what will happen in t_2. The indifferent customer (x_b) in t_1 solves the following equation:

$$(u - p_{bi} - x_bT_b) + (U - \mathrm{p_{bi}} - (\mathrm{U} - \mathrm{u}) + x_b(\mathrm{T_a} - \mathrm{T_b}) - x_b\mathrm{T_a})$$
$$= \big(u - p_{bj} - (1 - x_b)T_b\big) + (U - \mathrm{p_{bj}} - (\mathrm{U} - \mathrm{u}) + (1 - x_b)(\mathrm{T_a} - \mathrm{T_b})$$
$$- (1 - x_b)T_a).$$

After some simplifications, we obtain the following: $x_b = \frac{1}{2} + \frac{p_{bj}-p_{bi}}{2T_b}$, which corresponds to firm *i*'s demand and market share of the basic version. Note that $x_b = \frac{1}{2} + \frac{p_{bj}-p_{bi}}{2T_b}$ is also the indifferent customer of the static game of the first period or, equivalently, the indifferent customer when customers are completely myopic and make consumption decisions according to their period by period utility. The latter result follows from the fact that, with high customer switching costs, the optimal price in the second period makes the marginal customer indifferent between buying the basic version and buying the advanced version.

We can now write the profit function of a generic firm *i* as

$$\pi_i = x_b p_{bi} + x_b(p_{ai}^* - c),$$

where $p_{ai}^* = p_{bi} + \Delta$; $\Delta = (U-u) - x_b(T_a - T_b)$ and $x_b = \left(\frac{1}{2} + \frac{p_{bj} - p_{bi}}{2T_b}\right)$.

Taking the first-order conditions and simplifying (after imposing symmetry), we obtain an equilibrium price for the basic version:

$$p_b{}^* = T_b - \frac{[(U-u) - c - (T_a - T_b)]}{2}.$$

Because of symmetry, the demand for each firm in t_1 is

$$x_b{}^* = 1 - x_b{}^* = \frac{1}{2}.$$

The price of the advanced version then can be obtained by substitution.

Proof of Proposition 1a

First, $p_b{}^*(nsc) = T_b > p_b{}^*(sc) = T_b - \frac{(U-u)-c-(T_a-T_b)}{2}$. Second, with simple algebra, one can show that $p_a{}^*(nsc) = T_a + c \leq p_a{}^*(sc) = T_b + \frac{[(U-u)+c)]}{2}$ if $U - u - c \geq 2(T_a - T_b)$.

Proof of Proposition 1b

Let p_{avg} denote the average market price in t_2. With switching costs, $p_{avg}(sc) = 2T_b + \frac{(T_a - T_b)}{2} + c$; without switching costs, $p_{avg}(nsc) = T_b + T_a + c$. Thus, $p_{avg}(nsc) - p_{avg}(sc) = \frac{(T_a - T_b)}{2}$. It is easy to see that $p_{avg}(nsc) - p_{avg}(sc) > 0$ if $T_a > T_b$. Notice also that $\frac{\partial(p_{avg}(nsc) - p_{avg}(sc))}{\partial T_a} > 0$, such that the effect in Proposition 1b grows larger as the advanced version market becomes more (horizontally) differentiated.

Proof of Lemma 3

For simplicity of exposition, we analyze the case in which the differentiation parameter is the same for the two versions, $T_a = T_b = T > 0$ and $c = 0$. With some additional algebra, we can show that the results hold when $T_a > T_b > 0$ and $c > 0$. Assume that there exists an equilibrium in which only δ customers buy the advanced version in the scenario with high switching costs. Simple calculations using the results in Lemma 2 show that $p_b{}^*(sc) = T - \frac{\delta(U-u)}{2}$ and $p_a{}^*(sc) = T + \frac{(2-\delta)(U-u)}{2}$. It is easy to check that $\hat{u} - p_a{}^*(sc) < u - p_b{}^*(sc)$. Thus, $(1-\delta)$ customers do not buy the advanced version. It remains to be shown that $p_a{}^*(sc) = T + \frac{(2-\delta)(U-u)}{2}$ is the optimal price for the firm in t_2.

The firm could lower the price of the advanced version to the point at which all customers buy it, thereby increasing demand, though at a reduced price. If this option is preferable, it contradicts the idea that only δ customers buy the advanced version, so it cannot be an equilibrium. Let $\overline{p_a}(sc) = \hat{u} - u + p_b{}^*(sc)$, such that all customers buy the advanced version. The firm chooses $p_a{}^*(sc) = T + \frac{(2-\delta)(U-u)}{2}$ instead of $\overline{p_a}(sc) = \hat{u} - u + T - \frac{\delta(U-u)}{2}$ if and only if $\delta p_a{}^*(sc) > \overline{p_a}(sc)$, which holds if $\delta\left(T + \frac{(3-\delta)(U-u)}{2}\right) > (\hat{u} - u) + T$. It is straightforward to see that the inequality is more likely to hold for larger values of U and δ and smaller values of $\hat{u}$.

Extension 1: Relatively small switching costs

With sufficiently large switching costs, each firm is a monopolist in the second period, and its price is capped only by the price of its basic version. Here, we explore the case in which switching costs are relatively low before their removal.

Consider a customer who has acquired the basic version from firm *i*. If in t_2 such a customer values the advanced version, he/she can buy it from firm *i* or from firm *j*. In the latter case, the customer will have to pay, in addition to the price, a switching cost, *s*. To simplify the algebra we assume that $s < T_a$, such that at least some customers' preferences for the underlying characteristics of the advanced version can outweigh the switching costs, and *c = 0*. All other assumptions in the baseline model remain unchanged.

We solve the model by backward induction starting from period t_2. A customer who has bought from firm *i* in t_1 will be indifferent between the two firms in the choice of the advanced version if $U - T_a x_a - p_{ai} = U - T_a(1 - x_a) - p_{aj} - s$, which implies that $x_a = \frac{1}{2} + \frac{p_{aj} - p_{ai} + s}{2T_a}$. Instead, for customers who bought from firm *j*, the indifferent customer is $x_a{}' = \frac{1}{2} + \frac{p_{aj} - p_{ai} - s}{2T_a}$.

For small switching costs, finding equilibria in a model in which preferences across periods remain fixed becomes cumbersome. Indeed, profit functions are discontinuous around the location of the indifferent customer. Thus we focus on the more tractable case in which preferences are different and independent across periods.

In t_2, of all customers who value the advanced version, a share (x_b) has bought the basic version from firm *i*, while another share ($1 - x_b$) has bought the basic version from firm *j*. Firm *i* chooses p_{ai} to maximize $x_b\left(\frac{1}{2} + \frac{p_{aj} - p_{ai} + s}{2T_a}\right)p_{ai} + (1 - x_b)\left(\frac{1}{2} + \frac{p_{aj} - p_{ai} - s}{2T_a}\right)p_{ai}$. Firm *j* chooses p_{aj} to maximize $x_b\left(\frac{1}{2} + \frac{p_{ai} - p_{aj} - s}{2T_a}\right)p_{aj} + (1 - x_b)\left(\frac{1}{2} + \frac{p_{ai} - p_{aj} + s}{2T_a}\right)p_{aj}$. Solving the system obtained from the first-order conditions gives $p_{ai} = T_a + \frac{(2x_b - 1)s}{3}$ and $p_{aj} = T_a - \frac{(2x_b - 1)s}{3}$.

In t_1, the indifferent customer anticipates what happens when he/she values the advanced version in t_2. The probability that a customer who has bought from firm *i* will still buy from firm *i* is given by $\frac{1}{2}+\frac{\mathrm{p_{aj}}^*-\mathrm{p_{ai}}^*+s}{2\mathrm{T_a}}=\frac{1}{2}+\frac{5-4x_b}{6\mathrm{T_a}}s$, while the probability that the customer will buy from *j* is $\frac{1}{2}-\frac{5-4x_b}{6\mathrm{T_a}}s$. The probability that a customer who has bought from firm *j* will buy from firm *i* is given by $\frac{1}{2}+\frac{\mathrm{p_{aj}}^*-\mathrm{p_{ai}}^*-s}{2\mathrm{T_a}}=\frac{1}{2}+\frac{-1-4x_b}{6\mathrm{T_a}}s$, while the probability that the customer will still buy from firm *j* is $\frac{1}{2}+\frac{1+4x_b}{6\mathrm{T_a}}s$. So, the indifferent customer in period t_1 solves the following equation:

$$(u-p_{bi}-x_bT_b)+\left(\frac{1}{2}+\frac{5-4x_b}{6\mathrm{T_a}}s\right)\left(U-\mathrm{T_a}-\frac{(2\mathrm{x}_b-1)s}{3}-\frac{1}{2}\left(\frac{1}{2}+\frac{5-4x_b}{6\mathrm{T_a}}s\right)\mathrm{T_a}\right)$$

$$+\left(\frac{1}{2}-\frac{5-4x_b}{6\mathrm{T_a}}s\right)\left(U-\mathrm{T_a}+\frac{(2\mathrm{x}_b-1)s}{3}-\frac{1}{2}\left(\frac{1}{2}-\frac{5-4x_b}{6\mathrm{T_a}}s\right)\mathrm{T_a}-s\right)$$

After some simplifications, we obtain $x_b=\frac{(T_b+p_{bj}-p_{bi})+\frac{2s^2}{3\mathrm{T_a}}}{\frac{4s^2}{3\mathrm{T_a}}+2T_b}$. Note that for *s* = 0, we go back to the case in which there is no link between periods.

Firm *i* chooses p_{bi} to maximize: $\pi_i=x_bp_{bi}+\frac{1}{2\mathrm{T_a}}\left(\mathrm{T_a}+\frac{(2\mathrm{x}_b-1)s}{3}\right)^2$.

After computing the first-order conditions and imposing symmetry, we obtain the following equilibrium price for the basic version: $p_{bi}=p_{bj}=\mathrm{T_b}-\frac{2s}{3}\left(1-\frac{s}{\mathrm{T_a}}\right)$.[16]

The price of the advanced version can then be obtained by substitution. Thus, in a symmetric equilibrium $\mathrm{p_{ai}}=\mathrm{T_a}$ and $\mathrm{p_{aj}}=\mathrm{T_a}$. Finally, $p_{avg}=\mathrm{T_b}-\frac{2s}{3}\left(1-\frac{s}{\mathrm{T_a}}\right)+\mathrm{T_a}$.

Looking at the average price equation we can draw some conclusions. First, the removal of customer switching costs (i.e., *s = 0*) always leads to a greater average price. This effect is achieved through an increase in the basic version price while the advanced version price remains unchanged. Second, because $\frac{\partial(p_{avg}(nsc)-p_{avg}(sc))}{\partial T_a}=\frac{4\mathrm{s}}{3\mathrm{T_a}^2}>0$, the removal of customer switching costs generates a larger price increase when the advanced version market is more (horizontally) differentiated. Both findings mimic those we derive in the basic model.

Extension 2: Endogenous Quality

Consider the following version of the baseline model. In t_2, before choosing the optimal price for the advanced version, firms simultaneously invest to determine their respective quality of the advanced version. The quality of the advanced version of firm *i* is equal to $U_i=u+A_i$, where u is the

[16] We discard intrabrand price effects, which reflects the case in which the value that customers get from the advanced version is sufficiently higher than the value that they obtain from the basic version; specifically, $(U-u)-\frac{3}{2}(\mathrm{T_a}-\mathrm{T}_e)>\frac{2s}{3}\left(1-\frac{s}{\mathrm{T_a}}\right)$, which, given our assumptions on the parameters, always holds when *s* is small enough.

(exogenous) quality of the basic version, while A_i is a function of firm *i*'s investment. Investment to enhance the quality of the advanced version generates the following cost: $C(A_i) = \frac{aA_i^2}{2}$, where a > 0 is a scalar and is assumed to be small enough.[17]

We start first with the investment in quality in the case of high customer switching costs. In this case, customers cannot switch firms for the advanced version. Thus, the price of the advanced version will be the one we have obtained in Lemma 1, that is, $p_{ai}^* = p_{bi} + A_i - x_b(T_a - T_b)$. Note that an investment in quality has a positive direct effect on the price of the advanced version. Firm *i* chooses A_i to maximize $x_b(p_{ai}^* - c) - \frac{aA_i^2}{2}$. After solving the first order condition, one obtains that $A_i^* = \frac{x_b}{a}$.

We can now analyze the price of the basic version. Firms choose the optimal price of the basic version by anticipating their future investment in quality and their optimal choice of the price of the advanced version. In t_1, firm *i* maximizes the following profit function:

$$x_b p_{bi} + x_b(p_{ai}^* - c)$$

where $p_{ai}^* = p_{bi} + \frac{x_b}{a} - x_b(T_a - T_b)$ and $x_b = \left(\frac{1}{2} + \frac{p_{bj} - p_{bi}}{2T_b}\right)$.

Taking the first-order conditions and simplifying (after imposing symmetry), we obtain an equilibrium price for the basic version:

$$p_b^* = T_b - \frac{\left[\frac{1}{a} - (T_a - T_b) - c\right]}{2}.$$

Because of symmetry, the demand for each firm in t_1 is $x_b^* = 1 - x_b^* = \frac{1}{2}$. This also implies that the equilibrium level of quality will be $A_i^* = \frac{1}{2a}$. Further substitutions show that $p_{ai}^* = T_b + \frac{c}{2}$ and that the average price is $2T_b + \frac{T_a - T_b}{2} + c - \frac{1}{2a}$, which is lower than the average price when the quality of the advanced version is exogenous.

Consider now the case in which customer switching costs are zero. The model must be solved by backward induction. The indifferent customer in the advanced version is $x_a = \frac{1}{2} + \frac{p_{aj} - p_{ai}}{2T_a} + \frac{A_i - A_j}{2T_a}$. As expected, the demand of firm *i* increases when it offers a higher quality to the customers. Next, we can compute the optimal prices, given qualities. The best response functions of the two firms are:

$$p_{ai}(p_{aj}, A_i, A_j) = \frac{T_a}{2} + \frac{c}{2} + \frac{p_{aj}}{2} + \frac{A_i - A_j}{2} \text{ and } p_{aj}(p_{ai}, A_j, A_i) = \frac{T_a}{2} + \frac{c}{2} + \frac{p_{ai}}{2} + \frac{A_j - A_i}{2}.$$

[17] We assume that $a < \frac{1}{T_a - T_b + c}$.

Solving the system, one obtains: $p_{ai}(A_i, A_j) = c + T_a + \frac{A_i - A_j}{3}$ and $\pi_{ai}(A_i, A_j) = \frac{1}{18T_a}\left(3T_a + A_i - A_j\right)^2$.

We can now solve for the equilibrium qualities. Firm *i* chooses A_i to maximize $\pi_{ai}(A_i, A_j) - \frac{aA_i{}^2}{2}$. Assuming parameters satisfy the second order conditions, after imposing symmetry, we find that: $A_i{}^* = A_j{}^* = \frac{1}{3a}$. In turn, $p_{ai}{}^* = p_{aj}{}^* = c + T_a$. Thus, the equilibrium price does not change. Note that firms invest less in quality in this scenario compared to the high-customer-switching-costs case because in the latter they have captive customers and can appropriate a greater share of the value created by their investments in quality.

To summarize, the removal of customer switching costs generates a greater average price increment when the quality of the advanced version is endogenous vis-à-vis when it is exogenous. Because the investment in quality is lower after the removal of customer switching costs, profits will also experience a greater increment.

APPENDIX 2

TABLE A1. List of countries in this study

Country	MNP Adoption	Number of Competitors	Country	MNP Adoption	Number of Competitors
Hong Kong	2000Q1	6	Israel	2007Q4	4
Netherlands	2000Q1	5	Singapore	2008Q2	4
United Kingdom	2000Q1	4	Mexico	2008Q2	4
Switzerland	2000Q1	3	Egypt	2008Q2	3
Spain	2000Q4	3	Brazil	2008Q3	9
Norway	2001Q2	2	Macedonia	2008Q3	3
Australia	2001Q3	4	Malaysia	2008Q4	6
Denmark	2001Q3	4	Bulgaria	2008Q4	3
Sweden	2001Q3	3	Romania	2008Q4	5
Belgium	2002Q1	3	Turkey	2008Q4	3
Portugal	2002Q1	3	Dominican Republic	2009Q3	4
Italy	2002Q2	3			
Germany	2002Q4	4	Ecuador	2009Q4	3
France	2003Q2	3	Peru	2010Q1	3
Greece	2003Q3	4	Jordan	2010Q2	5
Finland	2003Q3	3	Thailand	2010Q4	7
Ireland	2003Q3	3	Albania	2010Q4	4
The U.S.	2003Q4	18	India	2011Q1	15
Lithuania	2004Q1	3	Georgia	2011Q1	7
Hungary	2004Q2	3	Kenya	2011Q2	4
Cyprus	2004Q3	4	Colombia	2011Q3	4
Austria	2004Q4	5	Ghana	2011Q3	5
Iceland	2004Q4	2	Bahrain	2011Q3	3
Estonia	2005Q1	3	Panama	2011Q4	4
Luxembourg	2005Q1	3	Vietnam	2011Q4	7
Malta	2005Q3	2	Chile	2012Q1	5
Slovenia	2005Q4	3	Belarus	2012Q1	5
South Korea	2005Q4	4	Moldova	2012Q4	4
Czech Republic	2006Q1	3	Nigeria	2013Q2	8
Slovakia	2006Q1	2	Kuwait	2013Q2	3
Poland	2006Q1	3	Russia	2013Q4	11
Croatia	2006Q1	3	UAE	2013Q4	2
Saudi Arabia	2006Q3	3	Azerbaijan	2014Q1	3
Oman	2006Q3	2	Armenia	2014Q2	4
South Africa	2006Q4	3	Honduras	2014Q2	3
Japan	2006Q4	4	El Salvador	2015Q3	5
Latvia	2007Q1	4	Kazakhstan	2015Q3	4
Pakistan	2007Q1	7	Senegal	2015Q3	3
Canada	2007Q1	11	Maldives	2016Q1	2
Morocco	2007Q1	3	Iran	2016Q3	6
New Zealand	2007Q2	2	Tanzania	2017Q1	8

Notes: The table shows the countries in our sample that implemented MNP up to 2017 Q1. Countries in our sample that have not implemented MNP as of 2017Q1 are as follows (competitors averaged for the period of study in parentheses): Afghanistan (5), Algeria (2), Andorra (1), Angola (1), Argentina (4), Bahamas (1), Bangladesh (6), Barbados (2), Belize (1), Benin (4), Bermuda (2), Bolivia (2), Bosnia and Herzegovina (2), Botswana (2), Burkina Faso (2), Burundi (4), Cabo Verde (1), Cambodia (5), Cameroon (2), Central African Republic (3), Chad (2), China (3), Congo (3), Costa Rica (2), Cote d'Ivoire (4), Democratic Republic of Congo (6), Djibouti (1), Equatorial Guinea (1), Ethiopia (1), Faroe Islands (1), Fiji (1), French Polynesia (1), Gabon (3), Greenland (1), Grenada (2), Guatemala (3), Guinea (4), Guinea-Bissau (2), Guyana (1), Haiti (2), Indonesia (7), Iraq (5), Isle of Man (1), Jamaica (2), Kyrgyzstan (6), Laos (3), Lebanon (2), Lesotho (1), Liberia (3), Macao (3), Madagascar (3), Malawi (2), Mali (2), Mauritania (2), Mauritius (2), Micronesia (1), Monaco (1), Montenegro (2), Mozambique (2), Myanmar (1), Namibia (2), Nepal (4), New Caledonia (1), Nicaragua (2), Niger (3), Palestine (1), Papua New Guinea (2), Paraguay (3), Philippines (5), Puerto Rico (6), Rwanda (2), Saint Kitts and Nevis (2), Sao Tome and Principe (1), Serbia (2), Seychelles (2), Sierra Leone (3), Solomon Islands (1), South Sudan (4), Sri Lanka (4), Sudan (2), Suriname (2), Swaziland (1), Syria (2), Tajikistan (5), Timor-Leste (2), Togo (2), Trinidad and Tobago (1), Tunisia (2), Turkmenistan (1), Uganda (5), Ukraine (8), Uruguay (2), Uzbekistan (5), Venezuela (3), Yemen (3), Zambia (3), Zimbabwe (3).

TABLE A2. Comparison of *ARPU* treated and control groups 8 quarters before and after MNP

MNP Implementation	***ARPU*(log) Control(1)**	**Obs. Control**	***ARPU*(log) Treated(2)**	**Obs. Treated**	**Difference (1) – (2)**	***p*-value**	**Obs. Combined**
8 quarters before	2.46	342	2.50	246	–0.04	0.62	588
7 quarters before	2.50	382	2.50	248	0.00	0.99	630
6 quarters before	2.47	353	2.53	262	–0.06	0.45	615
5 quarters before	2.55	334	2.48	266	0.07	0.46	600
4 quarters before	2.50	346	2.46	274	0.04	0.61	620
3 quarters before	2.45	343	2.46	280	–0.01	0.94	623
2 quarters before	2.40	338	2.44	281	–0.04	0.65	619
1 quarter before	2.45	324	2.42	280	0.03	0.72	604
MNP Implementation Quarter	2.39	353	2.52	336	–0.12	0.16	689
1 quarter after	2.34	331	2.52	330	–0.18	0.03	661
2 quarters after	2.37	308	2.51	327	–0.14	0.09	635
3 quarters after	2.28	294	2.52	321	–0.24	0.00	615
4 quarters after	2.36	278	2.53	320	–0.17	0.04	598
5 quarters after	2.30	299	2.54	318	–0.24	0.00	617
6 quarters after	2.23	291	2.52	316	–0.28	0.00	607
7 quarters after	2.32	253	2.53	304	–0.21	0.01	557
8 quarters after	2.29	267	2.53	304	–0.24	0.00	571

Notes: The table shows the *t*-test between control and treated groups that are constructed for Figure 1.

TABLE A3. Results of OLS regressions testing the effects of MNP on firms pricing strategy after introducing MVNO controls

Variables	**(1)** ***ARPU Prepaid* (log)**	**(2)** ***ARPU Postpaid* (log)**	**(3)** ***ARPU* (log)**	**(4)** ***ARPU Prepaid* (log)**	**(5)** ***ARPU Postpaid* (log)**	**(6)** ***ARPU* (log)**	**(7)** ***ARPU Prepaid* (log)**	**(8)** ***ARPU Postpaid* (log)**	**(9)** ***ARPU* (log)**
PostMNP	0.142	0.055	0.161	0.140	0.055	0.160	0.140	0.054	0.158
	(0.004)	(0.189)	(0.002)	(0.005)	(0.192)	(0.002)	(0.005)	(0.198)	(0.003)
Total MVNOs	–0.004	0.000	0.000						
	(0.020)	(0.956)	(0.959)						
Specialized MVNOs				–0.004	0.000	0.000			
				(0.017)	(0.895)	(0.856)			
Prepaid MVNOs							–0.008	–0.001	–0.001
							(0.010)	(0.735)	(0.506)
HHI	0.039	0.072	0.063	0.039	0.072	0.063	0.039	0.072	0.063
	(0.431)	(0.059)	(0.199)	(0.425)	(0.059)	(0.198)	(0.424)	(0.058)	(0.197)
GDP	0.190	0.154	0.105	0.191	0.155	0.109	0.215	0.161	0.121
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Penetration	–0.454	–0.051	–0.528	–0.450	–0.052	–0.532	–0.452	–0.056	–0.540
	(0.001)	(0.628)	(0.000)	(0.001)	(0.617)	(0.000)	(0.001)	(0.592)	(0.000)
Constant	2.351	3.259	3.093	2.349	3.258	3.090	2.338	3.255	3.083
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	6,542	6,542	6,542	6,542	6,542	6,542	6,542	6,542	6,542
R-squared	0.487	0.528	0.545	0.487	0.528	0.545	0.488	0.528	0.545
Number of firms	216	216	216	216	216	216	216	216	216
Firm fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm and remain consistent with alternative specifications. We construct three measures to account for entry rate of MVNOs. *Total MVNOs* (*Mean* = 0.178, *SD* = 0.705; min = 0, max = 13) measures the cumulative number of MVNO entries up to quarter *t* in each country. The variable includes both specialized MVNOs and those that target segments of prepaid and postpaid customers simultaneously. The *Specialized MVNOs* (*Mean* = 0.028, *SD* = 0.188; min = 0, max = 4) variable reflects the cumulative number of MVNO entries by operators that target either prepaid or postpaid segments, up to quarter *t* in each country. Finally, *Prepaid MVNOs* (*Mean* = 0.091, *SD* = 0.434; min = 0, max = 6) measures the cumulative number of MVNO entries by operators that target only the prepaid segment up to quarter *t* in each country. These measures only account for the number of entries by MVNOs and do not take exits into account.

TABLE A4. Results of OLS regressions showing MNP effect on service quality

Variables	(1) *Minutes of Use*[a] (log)	(2) *Data Usage*[a] (log)	(3) *CAPEX* (log)	(4) *4G Installed Base*
PostMNP	0.065	1.191	–0.083	–0.044
	(0.515)	(0.442)	(0.195)	(0.015)
Prepaid	–0.642	0.277		
	(0.000)	(0.902)		
PostMNP× Prepaid	–0.038	–0.789		
	(0.764)	(0.674)		
HHI	–0.022	0.375	0.103	–0.029
	(0.499)	(0.136)	(0.016)	(0.405)
GDP	0.105	–0.068	0.046	0.036
	(0.006)	(0.561)	(0.251)	(0.430)
Penetration	0.297	1.666	0.390	–0.165
	(0.008)	(0.024)	(0.010)	(0.078)
Constant	5.196	2.684	16.081	0.098
	(0.000)	(0.013)	(0.000)	(0.575)
Observations	9,762	2,004	12,387	2,021
R-squared	0.228	0.870	0.098	0.504
Number of firms	330	144	434	242
Firm fixed effect	YES	YES	YES	YES
Quarterly time fixed effects	YES	YES	YES	YES

Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm and remain consistent with alternative specifications. We compute the natural logarithm of *Minutes of Use*, *Data Usage*, and *CAPEX* to reduce their skewness. *Minutes of Use* (*Mean* = 4.988, *SD* = 0.752; min = 0.693, max = 7.979). *Data Usage* (*Mean* = 14.45, *SD* = 3.02; min = 1.60, max = 21.91). *CAPEX* (*Mean* = 16.79, *SD* = 1.95; min = 5.91, max = 22.88). *4G Installed Base* (*Mean* = 0.20, *SD* = 0.31; min = 0, max = 1). The sample size drops in some models due to missing values.

[a] While we do not have data on the breakdown of *Minutes of Use* by service type, we can estimate it indirectly through the following regression model:

$$Minutes\ of\ Use_{it} = \beta_0 + \beta_1 PostMNP_{it} + \beta_2 Prepaid_{it} + \beta_3 Prepaid_{it} \times PostMNP_{it} + \bar{\theta} Controls_{it} + \varepsilon_{it}.$$

The goal of this regression is to use the variation in prepaid share over time to estimate the average minutes provided in a prepaid plan (i.e., our measure of quality). This variable is captured by the parameter β_2, which measures the difference in *Minutes of Use* between prepaid and postpaid services. Eventually, we can estimate whether MNP has an impact on the prepaid plan's *Minutes of Use* using the parameter β_3. We follow a similar approach to estimate the effect of MNP on prepaid plan's *Data Usage*.

TABLE A5. Results of OLS regressions showing MNP effect on different country-level variables

Variables	**(1)** ***HHI***	**(2)** ***Number of Firms***
PostMNP	0.270	–0.039
	(0.108)	(0.802)
Constant	6.506	2.125
	(0.000)	(0.000)
Observations	10,045	10,045
R-squared	0.327	0.134
Number of countries	178	178
Country fixed effect	YES	YES
Quarterly time fixed effects	YES	YES

Notes: *P*-values are in parentheses. Robust standard errors are clustered by country. The unit of analysis is country-quarter. *Number of Firms* (*Mean* = 2.686, *SD* = 1.846; min = 1, max = 17) refers to the number of firms in each country in a given quarter.

TABLE A6. Results of OLS regressions showing the importance of conversion funnel business model

Variables	**(1)** ***ARPU*(log)**	**(2)** ***ARPU*(log)**
PostMNP	0.016	0.029
	(0.856)	(0.734)
PostMNP× All Funnel	0.198	0.193
	(0.035)	(0.039)
All Funnel		0.344
		(0.000)
HHI	0.047	0.048
	(0.007)	(0.004)
GDP	0.103	0.113
	(0.000)	(0.000)
Penetration	–0.177	–0.134
	(0.048)	(0.124)
Constant	2.813	2.541
	(0.000)	(0.000)
Observations	26,976	26,976
R-squared	0.428	
Number of firms	563	563
Firm fixed effect	YES	−
Firm random effect	−	YES
Quarterly time fixed effects	YES	YES

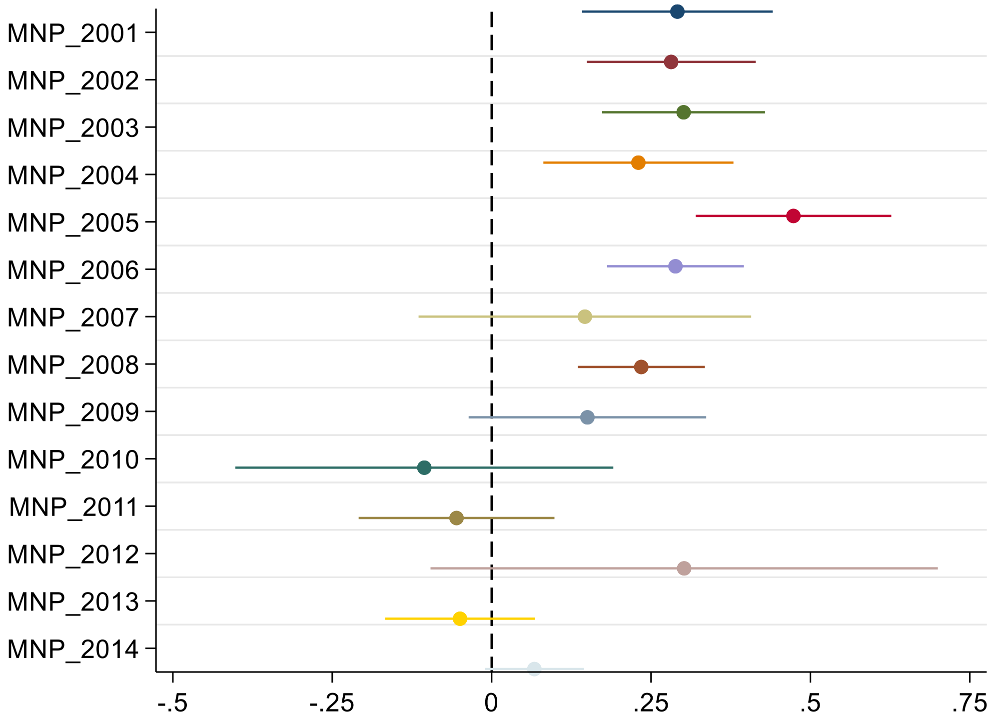
Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm and remain consistent with alternative specifications. *All Funnel* (*Mean* = 0.63, *SD* = 0.48; min = 0, max = 1) is equal to 1 if all firms in a given country in the pre-MNP period provide both prepaid and postpaid services simultaneously and equal to 0 otherwise.

TABLE A7. Event-study difference-in-differences

Variables	(1) ***ARPU*(log)**	(2) ***ARPU*(log)**
PreMNP(–3 Years)	0.009	–0.002
	(0.458)	(0.904)
PreMNP(–2 Years)	–0.006	0.003
	(0.497)	(0.758)
MNP Year	0.044	0.089
	(0.000)	(0.000)
PostMNP(+1 Year)	0.058	0.123
	(0.025)	(0.000)
PostMNP(+2 Years)	0.136	0.223
	(0.000)	(0.000)
PostMNP(+3 Years)	0.148	0.259
	(0.000)	(0.000)
PostMNP(+4 Years)	0.178	0.316
	(0.000)	(0.000)
HHI	0.015	0.027
	(0.642)	(0.334)
GDP	0.017	0.048
	(0.436)	(0.000)
Penetration	–0.696	–0.539
	(0.000)	(0.000)
Constant	3.078	3.025
	(0.000)	(0.000)
Observations	8,504	8,504
R-squared	0.231	
Number of firms	331	331
Firm fixed effect	YES	−
Firm random effect	−	YES
Year fixed effects	YES	YES

Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm. Firms located in countries that never implemented MNP are not included in this analysis.

TABLE A8. MNP coefficient estimates for different cohorts



Notes: The graph shows the cohort-specific point estimates (circle markers) and the intervals (colored bars) for MNP coefficients. The coefficients show the effects of MNP on *ARPU*(log) separately for each cohort between 2001–2014. Because there is no variation in treatment timing (MNP implementation) within each separate regression, this setup should avoid any bias affecting staggered difference-in-differences estimation.

TABLE A9. Stacked OLS regression

Variables	**(1)** ***ARPU*(log)**
PreMNP(–3 Years)	–0.017
	(0.024)
PreMNP(–2 Years)	–0.023
	(0.009)
MNP Year	0.033
	(0.015)
PostMNP(+1 Year)	0.041
	(0.254)
PostMNP(+2 Years)	0.071
	(0.026)
PostMNP(+3 Years)	0.093
	(0.001)
PostMNP(+4 Years)	0.102
	(0.000)
HHI	0.002
	(0.945)
GDP	0.008
	(0.821)
Penetration	–0.575
	(0.000)
Constant	4.117
	(0.000)
Observations	7,348
R-squared	0.975
Cohort-specific firm fixed effect	YES
Cohort-specific year fixed effect	YES

Notes: *P*-values are in parentheses. Robust standard errors are clustered by firm. The table shows event-study difference-in-differences estimates with unit and time fixed effects saturated with indicators for the specific stacked dataset.